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WEEKLY 10 April 2021

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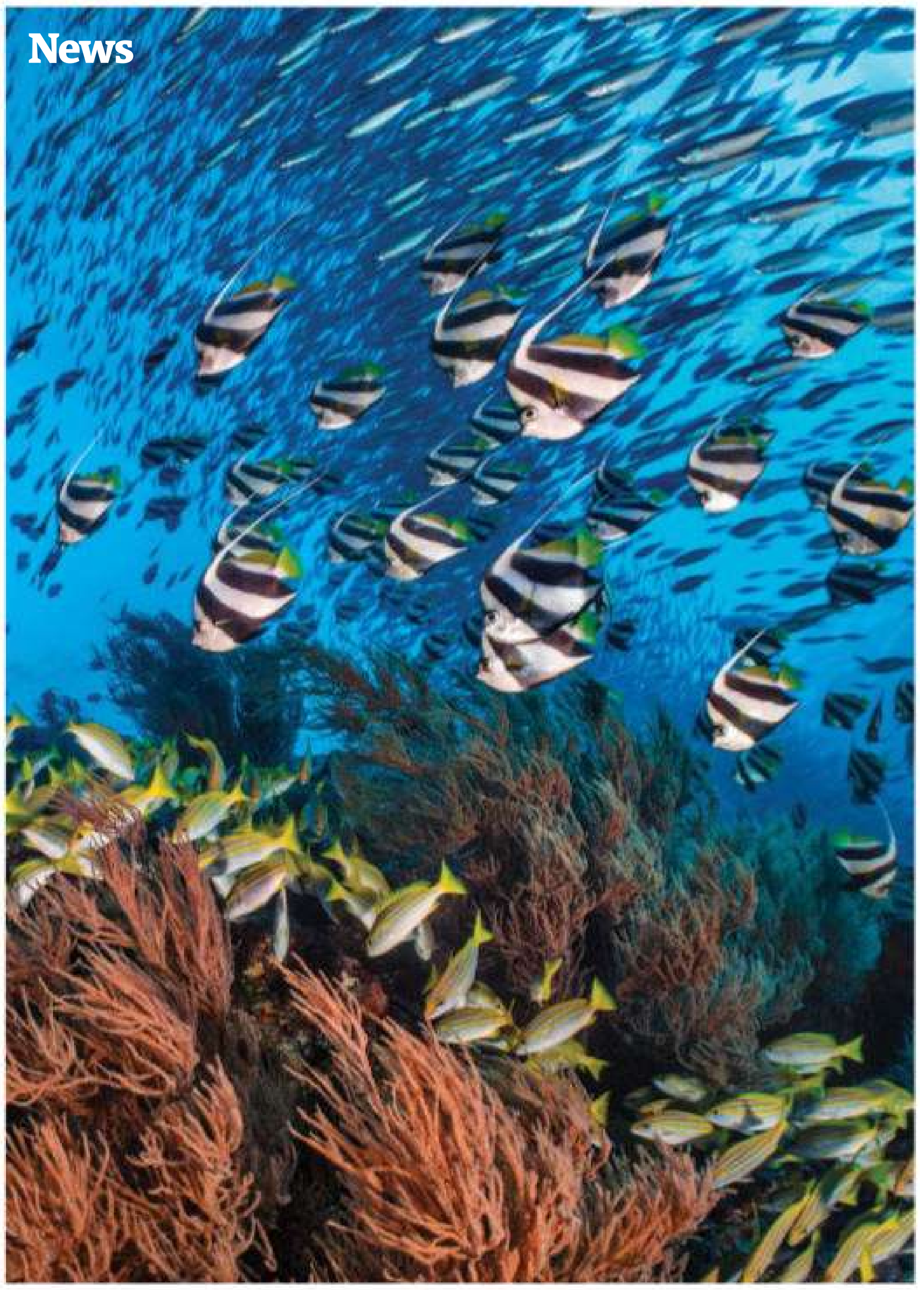

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Weekly

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How to live better Helen Thomson on tried-and-tested life hacks

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Sneeze fest Climate change will make hay fever worse in Europe

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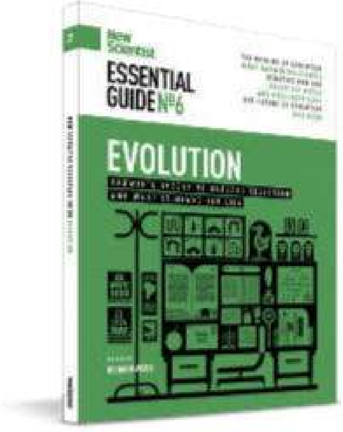

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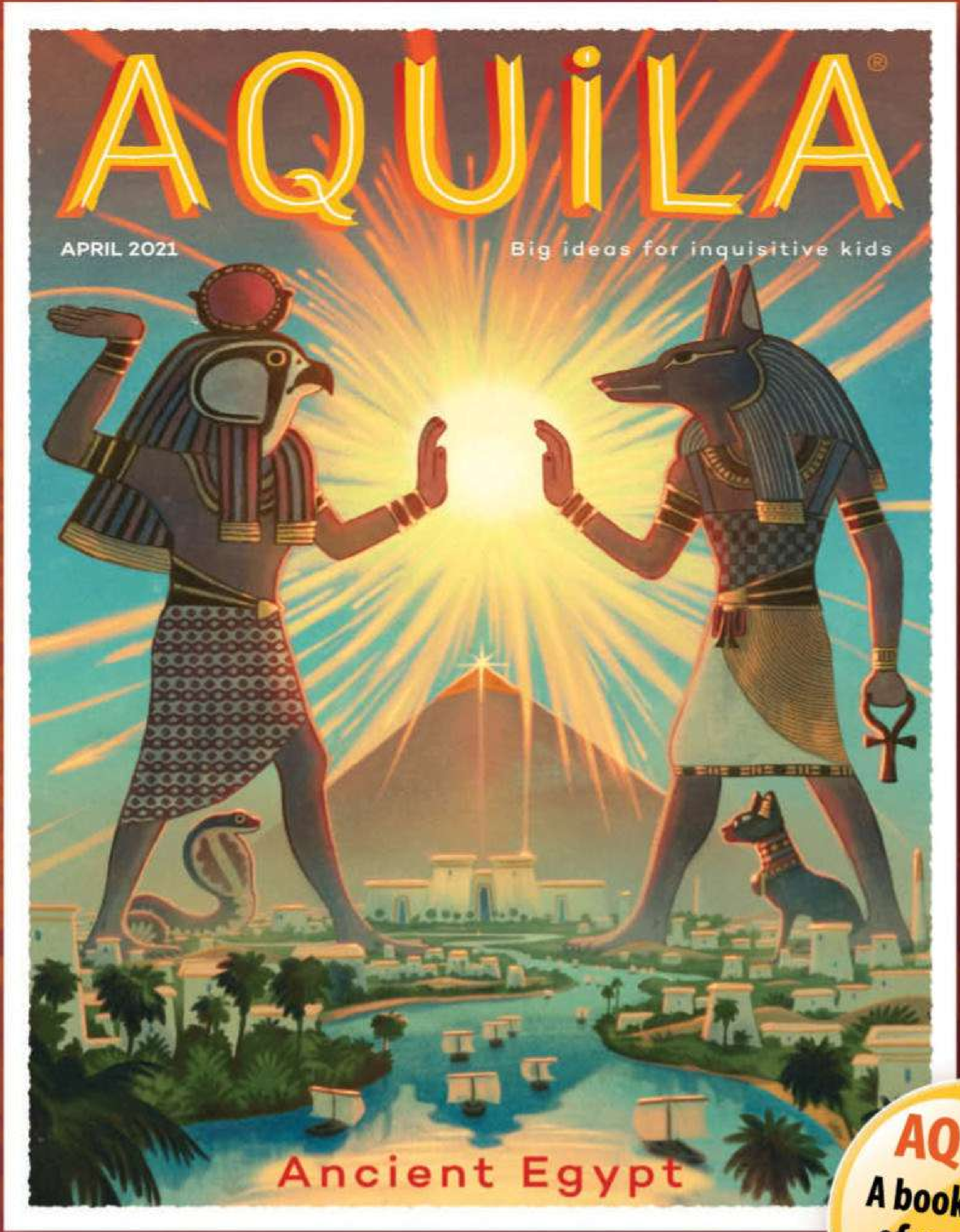

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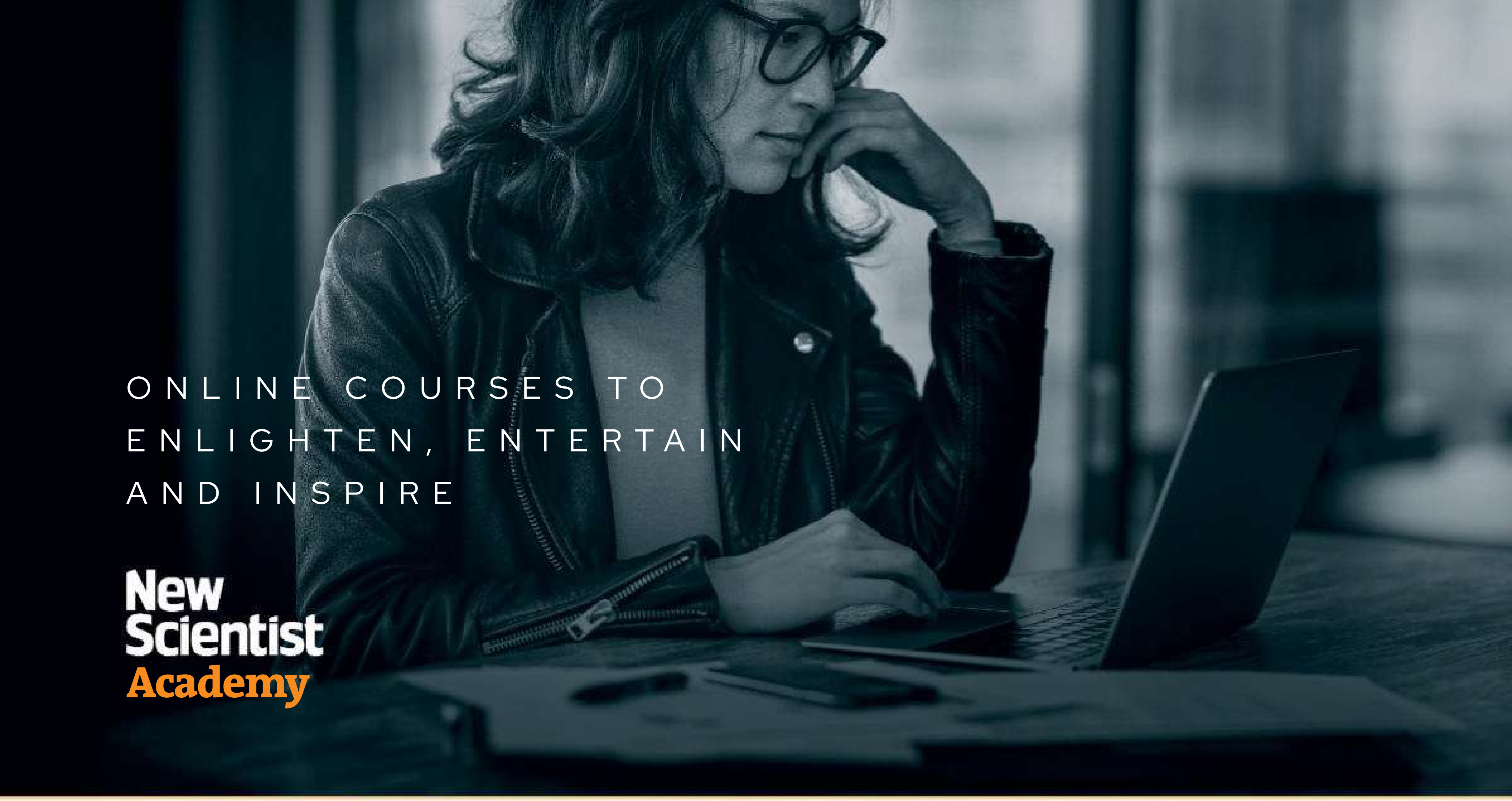

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Beautiful minds

Animal intelligence is widespread, so we need to rethink our relations with wildlife

CALL it human curiosity, but it is natural to wonder what a pet is thinking, or to ponder, as philosophers and latterly consciousness researchers have, what it is like inside the mind of a bat or a bird or an octopus. We are inching closer to cracking the secrets of animal minds – and they aren't what we expected.

From Snowball the dancing cockatoo to sheep that can recognise celebrities, there are plenty of examples of animals doing clever things. Nevertheless, such antics could be mere party tricks, not a manifestation of something resembling the "general" intelligence that allows us to think our way through life's challenges.

In fact, many biologists have long assumed that animals don't do much thinking at all, acting mostly on instinct instead. The idea was so ingrained that our curiosity didn't extend to testing it – until recently (see page 36).

Obviously, you can't put animals through human IQ tests. Nor would we necessarily want to, given that those tests provide only a limited and selective view of intelligence. But with a bit of ingenuity, you can devise a battery of tasks appropriate for a particular species.

> "We search for intelligent life elsewhere, but there is more on Earth than we imagined"

A growing number of animals are passing such tests. These include creatures with tiny brains, such as mice, and others, like ravens, that don't even have the brain structures we usually associate with intelligence. Clearly, humans aren't alone in possessing a flexible, problem-solving sort of brain – or indeed attributes that build on that, such as culture (see page 15).

So we should be careful what traits we describe as uniquely human. But equally we should be careful not to anthropomorphise too much: no one can even be certain that other people think in the same way they do, let alone animals.

These findings raise intriguing questions, such as how animals achieve what they do without language. And they provide further grounds for seeing our relationship with the wildlife around us more as one between equals. Much time and effort goes into searching for intelligent life elsewhere in the universe, but it turns out there is far more of it here on Earth than we imagined. We must value it for what it is. ▮

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UK Prime Minister Boris Johnson gives a media briefing on 5 April

Exiting lockdown

UK vaccine passport row

As restrictions ease in England and a third wave looks likely, divisive vaccine passports will be put to the test, reports **Adam Vaughan**

VACCINE passports for covid-19 are likely to become a "feature of our lives", according to a UK government review of the scheme, despite mounting political opposition to making proof of vaccination a condition of entry to workplaces, shops and venues.

Trials of vaccine passports, also known as certificates, will start shortly at specific events in England, including the FA cup final (see page 10), and run until mid-May, the UK government announced on 5 April. The idea is that they could play an important but temporary role in the UK and internationally. The review was published as the UK prime minister, Boris Johnson, confirmed the next phase of easing restrictions will go ahead in England as planned on 12 April.

The UK government said certification should "never be required" in settings including public transport and essential shops, a stance in line with the German government. Discussions on vaccine passports are being held across all four UK nations.

However, more than 70 MPs from across the political spectrum have launched a campaign to oppose vaccine certificates, which they say would be "divisive and discriminatory". The Labour party has indicated it is minded to oppose the measures if they are put to a parliamentary vote.

The UK government believes certificates are likely to be used until the end of the pandemic, whether it oversees them or not, because UK businesses could choose to implement them, and other countries have already begun requiring them at borders.

"I think some sort of certification is becoming almost inevitable for travel," says Melinda Mills at the University of Oxford, co-author of a recent Royal Society report on vaccine passports. Israel, which has some of the world's highest vaccination rates, has already introduced them, while the EU is planning a scheme in time for its summer holiday season.

The aviation sector has backed certificates to kick-start international travel.

Nonetheless, concerns remain. Mills says certificates risk excluding or discriminating against some groups, including people with allergies, pregnant women and children who cannot yet be vaccinated.

Introducing them before the end of July, the target date for all adults in the UK to have been offered a vaccine, would create age inequalities, she adds. It still isn't clear what the rules will be for children (see page 9).

> "As restrictions ease, vaccine passports could play an important but temporary role in our lives"

One way around this is for people who have tested negative for the coronavirus, or who can show they have antibodies from prior infection, to also be granted a certificate – an idea supported by the UK government.

There are also fears that digital passports that only work for certain smartphones could exclude people, as has happened in Saudi Arabia. The security of databases holding details of the certificates is another issue, along with concerns over civil liberties.

The UK's political row over vaccine certificates comes as minutes from a meeting of the government's scientific advisers show a third wave of the country's epidemic is "highly likely", according to new modelling. While vaccination rates mean another wave won't cause as many hospitalisations and deaths, the Scientific Advisory Group for Emergencies said it would still lead to cases of long covid and other health impacts.

Researchers at the London School of Hygiene & Tropical Medicine said most of the surge in covid-19 cases is likely to come from the UK government's plan to end all restrictions by 21 June, and that a small surge will be caused by shops reopening on 12 April. The next peak in cases in the UK is expected in summer or autumn. ■

Daily coronavirus news round-up
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Children and teenagers

Covid-19 vaccines for kids

Early trial results hint that vaccines could be safe for children, but how the virus behaves will determine their roll-out, reports **Helen Thomson**

ANDREW CABALLERO-REYNOLDS/AFP VIA GETTY IMAGES

Children attend their father's vaccine appointment in Virginia

COVID-19 vaccines are being trialled in children, with early results from Pfizer showing remarkable efficacy and tolerability. But whether any are approved for use this year may depend on how the virus behaves, say experts.

Recently, *The Daily Telegraph* reported that children in the UK will start being vaccinated against covid-19 as early as August.

When contacted by *New Scientist*, a spokesperson for the UK Department of Health and Social Care said that no decisions have been made on whether children should be offered vaccinations. "While clinical trials are under way to test the efficacy and safety of covid-19 vaccines in children and young adults, these trials have not concluded yet," they said. "We will be guided by the advice of our experts on these issues, including the Independent Joint Committee on Vaccines and Immunisation (JCVI)."

"Pfizer has announced the first results for any covid-19 vaccine in kids, and they look promising"

"I think it is very unlikely that the JCVI will have enough information from the clinical trials of current vaccines to recommend immunising teenagers or children in the summer this year," says Saul Faust, professor of paediatric immunology and infectious diseases at the University of Southampton, UK. "The only situation that could change this would be the rapid spread of a new, more dangerous mutation. But with the current timetable for ending lockdown and the success of the adult immunisation programme, this is not something I expect to happen."

Trials of covid-19 vaccines in children are needed in order to work out the appropriate dose, as well as to ensure they are safe and have no unexpected side effects.

Older children tend to be vaccinated in trials first, followed by younger children. "The dose we give adults is likely to be OK in teenagers, but if too many minor side effects, like fever or arm pain, occur then we can lower the dose as we go down to younger – and therefore smaller – children," says Faust.

On 31 March, Pfizer announced the first results for any covid-19 vaccine in children. In a large-scale, phase III study of children aged 12 to 15 years old with and without prior covid-19 infection, the vaccine had a 100 per cent efficacy and was described by Pfizer as being well tolerated. This tends to mean that any overt adverse effects of a drug can be tolerated by those taking it.

100%

The efficacy of the Pfizer vaccine in a large-scale trial in children

The trial included 2260 children in the US, half of whom received two doses of the vaccine, while the rest were given a placebo. Eighteen cases of covid-19 occurred in the placebo group, compared with none in the vaccinated group. Side effects were similar to those seen in 16 to 25-year-olds.

Pfizer says that it plans to submit the data to the US Food and Drug Administration (FDA) and request the use of the vaccine in children over the age of 12 as quickly as possible. Last week, the company also began a trial of the vaccine in children aged 6 months to 11 years old.

In the UK, the team behind the Oxford/AstraZeneca vaccine has

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Evidence-based parenting advice for the pandemic
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started a smaller, phase II trial in 6 to 17-year-olds. It involves 300 participants, and up to 240 of these will receive the covid-19 vaccine. The rest will get a meningitis vaccine, which has been shown to be safe in children but may cause similar reactions, such as a sore arm.

After this initial safety trial, there is likely to be a bigger study of around 4000 to 6000 children, says Faust, which would look at dosing and efficacy. It is only at this point that you would expect to see the JCVI endorse the roll-out of the vaccine in children in the UK.

Even when we do have data from larger trials, the JCVI will probably base its decision on whether to roll out the vaccine on how much community transmission there is and how much children are contributing to it, says Faust.

Teenagers first

Currently, few children are thought to be at risk of severe covid-19. However, children can transmit the virus and add to the overall risk of a dangerous mutation occurring as it passes between individuals. In addition, there has been a slight increase in infections among children aged 11 to 15 years old in England, according to the latest data from the Office for National Statistics.

Therefore, it is likely that teenagers will be immunised first, followed by younger children, says Faust.

"If we are to reach herd immunity through vaccination, we will definitely need to vaccinate everybody who might be infectious, and that will include children," said Peter English, former chair of the BMA Public Health Medicine Committee, in a statement. "In terms of priorities, older children will be a higher priority, because they are more likely to infect others."

Whether children and pregnant women are vaccinated will affect the use of controversial vaccine passport schemes (see "Vaccine passports for kids?", below).

There are several other trials of covid-19 vaccines in children under way. CanSino Biologics, based in Shanghai, China, is developing a vaccine similar to the Oxford/AstraZeneca one. Researchers there are analysing initial data from a phase II trial carried out in Taizhou, Jiangsu province, in 30 children aged between 6 and 12 years old, who were each given two shots.

Johnson & Johnson has also announced plans to study its vaccine in younger people, starting with those aged 12 to 17 years old, with results expected "later this year", said CEO Alex Gorsky at a *Washington Post* Live event on 4 March.

> "If we are to reach herd immunity through vaccination, we will need to vaccinate children"

He said the firm was working with the FDA to ensure the right information was collected for rapid approval, and that he was hopeful children in the US would have a vaccine available by the end of the year. Moderna has also said it plans to test its covid-19 vaccine in 12 to 17-year-olds.

A representative from New York-based Codagenix told *New Scientist* they think their vaccine will be particularly well-suited for children as it is administered via intranasal drops rather than an injection. However, it is currently only in a phase I trial in adults.

Some firms are planning vaccine studies in pregnant women in their second and third trimesters. "All we can say at the moment is that they are coming," says Chrissie Jones at the University of Southampton, UK, who specialises in vaccines given during pregnancy. She says Johnson & Johnson is likely to start its study in pregnant women in the US in May, with Pfizer beginning shortly after this in the UK. ▮

Vaccine passports for kids?

Vaccine passports, used to confirm that people have a lower risk of transmitting covid-19, either because of prior infection or a vaccine, are being considered by many countries.

Whether children will need them is unclear. Several countries have already issued them to adults. In January, Saudi Arabia created a vaccine passport that works using an app. In February, Israel rolled out a QR code-based "green pass" that people can present as proof of vaccination, which some Israeli businesses and places of worship now require. Meanwhile, the European Commission is developing a digital green certificate to allow people to travel between the EU's member states, and the UK government is about to start conducting trials (see page 7).

The EU unveils its vaccine passport scheme for travellers this summer

MONASSE THIERRY/ANDBZ/ABACA/ABACA/PA IMAGES

Vaccine passports are controversial, in part because it isn't clear how effective vaccination or prior infection is at reducing transmission of the virus. They also risk excluding or discriminating against groups of people, such as pregnant women, and may widen social divisions if the decision on whether to use them is left to organisations.

The aviation industry has been supportive of them, but it isn't clear whether children would be included in any requirements for travel. "I could see them potentially being introduced [for children] for international travel, but it seems unlikely," says Tom Sasse at London think tank the Institute for Government.

However, Elliot Jones at the Ada Lovelace Institute, UK, points out that in Israel, children older than 1 face the same green pass restrictions as adults, and can be added to a parent's pass if they can prove recovery from covid-19. So vaccine passports for children in other areas "wouldn't be unprecedented internationally", he says. **Helen Thomson and Adam Vaughan**

Events

Concerts turned into live trials

Partygoers become guinea pigs in experiments on the safety of mass gatherings

Vivian Song

FOR a few hours on a Saturday afternoon in March, Simone van Erp did what, for much of the planet right now, would be unthinkable. She took off her mask, brushed up against strangers, danced, sang and shouted as loud as she could – droplets and aerosols be damned – as DJs at the Ziggo Dome in Amsterdam, the Netherlands, spun to a rapturous crowd of 1300.

"Everyone was really happy, enthusiastic, screaming and laughing, it was crazy," says van Erp. "It was a good feeling. You could see that everyone missed normal life."

It has been a year since much of the world has been able to dance and sing in a hot, crowded venue. Now studies are offering clues as to how we can safely reintroduce large gatherings into our lives.

During the early days of the coronavirus pandemic, it became clear that mass gatherings can be superspreader events, where just a few infected people can spark a large outbreak. In February 2020, before lockdowns began in the US, a two-day conference in Boston with 175 attendees was identified as the source of an estimated 20,000 cases of covid-19 across the Boston area by May.

Now, with mass vaccinations gathering pace globally, while the live entertainment sector typically remains hamstrung, many nations are conducting research with the goal of bringing back large events.

France is planning to conduct experimental stadium concerts in Paris and Marseille. So far, about 2000 students with no underlying health risks have been enlisted to attend two separate concerts in Marseille organised by the French National Institute of Health and Medical Research. Attendees will be tested the day before the event, but not told their result to allow for the presence of infected individuals. Concertgoers will wear surgical grade N95 masks and be required to socially distance.

KOEN VAN WEEL/ANP/AFP VIA GETTY IMAGES

Visitors to the Ziggo Dome in Amsterdam, the Netherlands, danced side by side as part of a large experiment

The goal is to look at the transmission rates of infected people when safety measures are in place. Attendees will be tested for the two weeks after the event. The results will also be compared with a control group of 1000 people who won't be at either concert.

Carefree dancing

In the Dutch experimental event, participants were put in one of six bubbles, each with varying degrees of restrictions in terms of mask-wearing, distancing and movement. Van Erp was in the restriction-free group that could sing and dance alongside one another without a mask.

"I really missed physical touch," she says. "To be amongst so many people again felt really good."

While the results of that experiment aren't yet available, the findings from one of the first large-scale gatherings in Germany since the pandemic began were released in October 2020, offering insight into how best to safely reopen mass gatherings.

Dubbed RESTART-19, the experiment, led by Stefan Moritz at University Hospital Halle in Germany, involved around 1200 participants. They attended a day-long pop concert last August at a stadium in Leipzig, leaving and re-entering three times, with each performance under different conditions: no restrictions, moderate distancing and strict physical distancing. Everyone wore N95 masks and had tested negative for the coronavirus 48 hours beforehand. They also carried contact-tracing devices that collected data on their movements and the duration of sustained contact with others.

"I really missed physical touch. To be amongst so many people again felt really good"

After feeding the data into computer simulations that tracked patterns of aerosol and droplet distribution, Moritz's team concluded that with rigorous safety and hygiene rules – namely pretesting, the use of face masks and physical distancing – the superspreader effect previously associated with mass gatherings has "minimal effects" on the overall number of infections within the community.

From the study, the team recommended the compulsory use of masks and a physically distanced seating plan at concerts, and that the venue be accessed via as many entry and exit points as possible to help keep the flow of people moving. Likewise, waiting areas, which could include coat check and ticketing, should be moved outdoors and food served

Participants in the RESTART-19 study in Germany were tested for coronavirus before a gig

UNIVERSITY MEDICINE HALLE, GERMANY

in seated areas to prevent overcrowding. The team also concluded that poor ventilation in indoor venues could drastically increase the risk of transmission.

"If you use an outdoor stadium at half capacity, you will not have a problem in my opinion," says Moritz.

But social distancing isn't always feasible or desirable, especially where dancing is involved. Doing away with it altogether is likely to involve lots of testing.

One experiment in Barcelona, Spain, on 27 March saw 5000 mask-wearing concertgoers gather shoulder to shoulder, after testing negative with an antigen test that took 10 minutes to turn around. The researchers will follow up over two weeks to monitor positive cases.

The UK government is also looking at ways to loosen social distancing measures at mass events. It recently created the Events Research Programme, which will study the impact of things like enhanced testing and vaccine certificates at upcoming events, including the FA Cup final and the World Snooker Championship.

While the results of RESTART-19 offer hope, Calum Semple at the University of Liverpool, UK, says we need to take a holistic approach to mass gatherings. Although it may seem safer to enjoy a classical music concert or attend a football match at an outdoor stadium than go to a rave, he says it is important to look at what happens before, during and after the event.

"What really hits the population is when spectators of a football game share a 30-seater minibus for 2 hours or when they huddle in the back of a beer tent or pub before the event on a wet day," he says. "Nothing is without risk."

Briefing

AstraZeneca blood clot link

What are the safety concerns related to the covid-19 vaccine, and should we be worried, asks **Clare Wilson**

LAST week, Canada joined several European countries in suspending use of the Oxford/AstraZeneca coronavirus vaccine in younger age groups. The decision follows a study suggesting a link between blood clotting events and the jab. Should people be worried?

What are the safety fears?

A small number of blood clot events have been recorded after people received the Oxford/AstraZeneca vaccine, most in middle-aged adults. A review by the European Medicines Agency (EMA) said the vaccine was safe to use, but France, Sweden, Finland, Iceland and Germany have restricted its use to people over a certain age, from 55 and up, depending on the country.

The AstraZeneca vaccine being drawn into a syringe in Mexico

NURPHOTO/PA IMAGES

Why, if it was deemed safe?

In March, the EMA reviewed the vaccine. The number of blood clotting events reported after vaccination, both in trials and after vaccine roll-outs, was lower than you might expect in an unvaccinated population. The EMA concluded that the vaccine isn't linked with a raised risk of blood clots overall.

However, the EMA found that, in younger people, the vaccine may be associated with very rare cases of blood clots coupled with low levels of platelets. This included a rare type of clot in the brain, called cerebral venous sinus thrombosis (CVST).

How many blood clot events have there been?

About 20 million people in the UK and European Economic Area had received the vaccine as of 16 March. At this time, the EMA had found 25 cases of unusual blood clotting in this population. Last week, Germany said it had identified 31 cases of CVST in the country.

What does the new study show?

Andreas Greinacher at Greifswald Medical School in Germany and his colleagues say they have identified a mechanism behind the blood clotting events. The group calls this process vaccine-induced prothrombotic immune thrombocytopenia (VIPIT).

The team studied nine vaccine recipients who later had CVST or blood clots and low platelet levels, and did blood tests on four. All four had signs of a very rare low-platelet syndrome usually caused by a reaction to heparin (*Research Square*, doi.org/f4gb). The team says this suggests the vaccine caused the syndrome. AstraZeneca hasn't replied to requests for comment.

Could there be other explanations?

This small study has limitations. It doesn't compare the number of people with this syndrome with the rate in unvaccinated people, said Adam Finn at the University of Bristol, UK, in a statement. Two of the people had a pre-existing blood clotting disorder and it isn't stated whether any had recently had covid-19, which can cause an increased risk of blood clots.

In general, some clots attributed to the vaccine could be caused by a natural infection, says Leonard Yeo at the National University Hospital of Singapore, who described 14 cases of CVST caused by covid-19 in unvaccinated people.

Another issue is that most cases have occurred in women under 55, a group with a higher rate of blood clots, because the contraceptive pill raises the risk of them. Perhaps some CVST cases being attributed to the vaccine are simply the usual background rates, says Beverley Hunt, medical director of charity Thrombosis UK.

How dangerous are the blood clotting events?

They can be deadly. In the new study, four of the nine affected have died and one is in hospital.

What is the takeaway message?

At the time of going to press, the EMA, the UK Medicines and Healthcare products Regulatory Agency (MHRA) and the World Health Organization say that the benefits outweigh any risks. "Our advice remains that the benefits of the AstraZeneca vaccine in preventing covid-19 and its complications continue to outweigh any risks and you should get the vaccine when invited to do so," says June Raine, CEO at the MHRA.

> "Our advice remains that the benefits of the vaccine continue to outweigh any risks"

What happens next?

The EMA and MHRA continue to investigate. It is possible that more countries will restrict use of the vaccine as a precautionary measure, says Hunt, who is assessing the risk with the MHRA. "Everyone is working flat out on this."

Climate change

Aliens may also face global warming

Humans have triggered a new geological epoch, the Anthropocene. Aliens could do the same

Ibrahim Sawal

MOST planets inhabited by advanced civilisations would be likely to face catastrophic climate change as a result of burning fuel, researchers have found.

Human activity has had a geological impact on Earth, putting it into a new epoch known as the Anthropocene. Adam Frank at the University of Rochester, New York, and his colleagues wanted to know if the same thing might happen on other Earth-like planets.

The researchers began with the assumption that "exocivilisations" would arise on planets with initial carbon dioxide levels that weren't detrimental to life forming and would at first generate energy through combustion, just as humans have done. They also looked at whether a planet's distance from its star would have an impact. "Essentially we asked, if Earth was moved, would civilisations still trigger a climate change," says Frank.

Each planet was also assumed to have started with a temperature of around 14°C. Those closer to the star would receive more heat and so would begin with less CO_2 in their atmosphere, while further-away ones would begin with more.

The researchers used climate models to see what would happen to Earth-like planets within a star's habitable zone – the region in which liquid water can exist on a planet's surface – under these assumptions as the population grew. They found that around 60 per cent of such planets would undergo climate change caused by Anthropocene-like conditions, and population growth would be limited by the increase in temperature.

This was more common on the low-carbon-atmosphere planets closer to their host star, which would have a higher climate sensitivity, a measure of how much the planet warms in reaction to changes in the levels of CO_2. The team found that even small CO_2 increases on these planets would be enough to trigger a climate change event that could harm the population.

For planets on the outer edge of a star's habitable zone, which would begin with thicker CO_2 atmospheres, climate sensitivity would be lower and civilisations could drive CO_2 levels higher without affecting their population. The team found that these populations would reach the planet's carrying capacity, growing to sizes that are unsustainable for the amount of resources on the planet, before climate change had a chance to take effect (arxiv.org/abs/2103.06330).

These findings suggest that inducing climate change would be a common problem for growing societies on any habitable planet. "Civilisations and planets work together," says Frank. But Jim Kasting at Pennsylvania State University says we can't assume that life on these planets would have the same heat-tolerance levels as humans do.

Frank says the research can also help us understand the climate situation here on Earth. "The question now is: do we drive the planet off a cliff, or do we drive the planet to safety?"

Climate change might be a common problem for inhabited planets

NASA, ESA, M. KORNMESSER

Animal behaviour

Female sheep prefer to mate with non-dominant males

WHEN ewes get the choice, they favour mating with a subordinate male than a dominant one.

Dominant rams usually mate with ewes much more often than lower-ranking rams do. But they can run out of sperm from mating so much in a short period of time. And if they fathered every lamb in a flock, the group would have less genetic diversity, which can lead to malformations and inheritable conditions. Ewes, which generally mate with several males when they are in heat, could have their own strategy to prevent inbreeding, says Rodolfo Ungerfeld at the University of the Republic in Uruguay.

To test this, he and his colleagues first ranked male hierarchy among eight rams by placing two of them at a time with a ewe in heat to see which one stood closest to her for the longest time. Domestically raised sheep usually show dominance through subtle body language instead of violent fighting.

Then they put the rams in pairs of one dominant and one subordinate male and tied them up at opposite corners of a large pen. They let the ewes loose in the pen one at a time, while they were in heat, until all 28 ewes had chosen between the rams.

The team found that ewes spent more time with subordinate rams – on average three times longer. Ewes also mated with the subordinate rams twice as often as the dominant ones. A quarter of the ewes refused to approach the dominant ram at all (*Applied Animal Behaviour Science*, doi.org/f4dr).

The findings make sense for a species in which sperm from different males compete for the female's eggs in the reproductive tract, says Andrew McLean at the University of Melbourne in Australia. It could also simply be that ewes prefer the gentler subordinate rams, says Ungerfeld.

Christa Lesté-Lasserre

When it comes to mating, gentle rams win over ewes

DAVID TIPLING/2020VISION/NATUREPL

Archaeology

Bronze Age dogs ate little meat and were fed on cereal

Michael Marshall

MANY early domestic dogs ate almost no meat. Dogs living around 3000 years ago in what is now Spain were instead fed cereals, such as millet, by their owners.

Although the diet may reflect the fact that meat was relatively scarce among human societies at the time, feeding dogs with cereals could have been advantageous, says Silvia Albizuri at the University of Barcelona in Spain. It may have been a way to ensure the dogs had plenty of energy for the strenuous work of herding and guarding livestock, she says, particularly since these dogs "were not pets as we conceive them nowadays".

Albizuri and her colleagues studied the remains of 36 dogs from Can Roqueta, an archaeological site near Barcelona. It lies on a plain near the coast and was inhabited from the Stone Age onwards. The dogs lived in the Bronze Age and Iron Age, between 1300 and 550 BC, and had been buried in pits.

The researchers obtained protein from the dogs' bones and focused on the carbon and nitrogen atoms in the samples, which give an indication of what the animals ate.

The dogs' diets differed considerably. While nine of them ate plenty of meat and 10 were omnivorous, the rest ate mostly plants – and some had isotope ratios that could barely be distinguished from those of the cattle they once guarded (*Journal of World Prehistory*, doi.org/f4cj).

The finding adds to the evidence that many early domestic dogs ate little meat, says Albizuri. This trend is thought to have begun with the advent of farming. "When human societies began to domesticate plants during the Neolithic period, hunting decreased and the human diet was based mainly on vegetables," she says. "Dogs began to be fed on plants, mainly cereals."

Environment

The dinosaur-killing asteroid made the Amazon possible

Leah Crane

SCIENCE PHOTO LIBRARY/ALAMY

South American rainforests used to be mostly coniferous

TODAY'S tropical rainforests came about because of the huge asteroid strike thought to have wiped out the dinosaurs.

Before the asteroid hit the Yucatán peninsula in what is now Mexico, South America's rainforests were made up of vastly different greenery than the abundance of flowering plants they now contain.

"If you returned to the day before the meteorite fall, the forest would have an open canopy with a lot of ferns, many conifers and dinosaurs," says Carlos Jaramillo at the Smithsonian Tropical Research Institute in Panama. "The forest we have today is the product of one event 66 million years ago."

Jaramillo and his colleagues analysed tens of thousands of samples of fossilised pollen and leaves found in northern South America that dated to the part of the Cretaceous period just before the asteroid hit, and just after the impact, in the Palaeocene epoch.

They found that plant diversity declined by 45 per cent after the impact and took 6 million years to recover. Insect bites on fossilised leaves showed that insect diversity also took a nosedive (*Science*, doi.org/gjmxqx).

The rainforests of South America changed in the aftermath of the catastrophe. Most of the cone-bearing plants and ferns disappeared, and the rainforests became dominated by flowering plants called angiosperms. A thick canopy allowed only a little light to reach the ground.

45%

Plant diversity lost in South American rainforests after the asteroid struck Earth

"I think the number one lesson here is unpredictability," says Ellen Currano at the University of Wyoming. "When you have these major perturbations, they change the rules of the whole ecosystem."

Jaramillo and his colleagues suggest several reasons why the asteroid may have caused this major change. For one, the impact probably killed most of the large, herbivorous dinosaurs that once trampled down and ate the lower levels of the forests.

Plus, the ash that settled out of the sky after the impact may have served as fertiliser, creating a nutrient-rich soil that favoured fast-growing angiosperms over other plants. Angiosperms also appear to have been more ecologically diverse before the impact, which would have made it easier for some of them to bounce back afterwards.

"We love the way it ended up, this incredibly diverse, really structurally complex forest, but right now, we are living through a mass extinction caused by humans and, again, whole ecosystems are being set on a different path," says Bonnie Jacobs at Southern Methodist University in Texas.

"In the case of the rainforest, we might like the final product, but all those animals that were alive in the Cretaceous did not," she says.

Understanding how this major event shaped the rainforests can help us put into perspective how these biodiversity hotspots are reacting to deforestation today and how long they could take to recover, says Jaramillo.

"At some of the places we studied, I could see right in front of my eyes how this forest that has taken 66 million years to build was gone in a day, and the rate of deforestation is staggering," he says. "We know from this study that it takes a long time to build these diverse forests back: you can't chop down the forest and think, 'Oh, tomorrow I'll plant more trees.'"

Robotics

Living robots made from frog skin cells get a design upgrade

Krista Charles

A MICROSCOPIC, living robot that can heal and power itself has been created out of frog skin cells.

Xenobots, named after the frog species that the cells come from, *Xenopus laevis*, were first described last year. Now the team behind the robots has improved its design and demonstrated new capabilities.

> **"When you liberate skin cells from their normal context, they can build other things"**

To create the spherical xenobots, Michael Levin at Tufts University in Massachusetts and his colleagues extracted tissue from 24-hour-old frog embryos. The tissue formed into spheroid structures after minimal physical manipulation.

Where the previous version of the xenobots relied on the contraction of heart muscle cells to move themselves forwards, these new xenobots swim around faster, being self-propelled by hair-like structures on their surface. They also live between three and seven days longer than their predecessors, which only lasted about seven days, and have the ability to sense their environment to some extent, turning red when exposed to blue light.

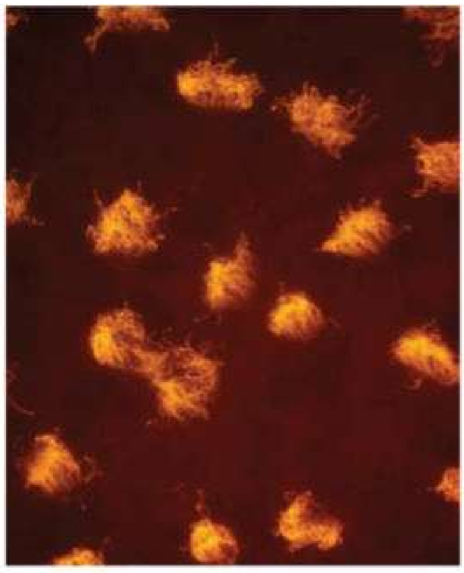
"The fundamental finding here is that when you liberate skin cells from their normal context, and you give them a chance to reimagine their multicellularity, they can build other things than what they normally build," says Levin. "To me, one of the most exciting things here is plasticity. This idea that even normal cells, not genetically modified, with a normal frog genome, are in fact capable of building something completely different."

The xenobots, which are between a quarter and half a millimetre in size, operate in robot swarms, meaning that a group of individual xenobots can work together to complete a task (*Science Robotics*, doi.org/f4f5).

Because they are created from cells, the xenobots eventually break apart and are totally biodegradable, says team member Douglas Blackiston, also at Tufts University. As a result, he hopes that they can be used for biomedical and environmental applications.

"Roboticists have been looking at swarm intelligence for a long time; biologists have been studying swarm intelligence in organisms. This is something in between, which I think is kind of interesting," says team member Josh Bongard at the University of Vermont. "It sort of suggests, to me at least as a roboticist, is this a better path to making swarms of useful machines than it is to make swarms out of traditional robotic parts?"

These xenobots are less than a millimetre in size



DOUGLAS BLACKISTON

Previous attempts at creating living robots, such as a wirelessly controlled cockroach, have involved manipulating live animals, raising ethical concerns. Xenobots differ from these because they are made entirely of living cells.

"The approach here is maybe ethically the least problematic because everything is in vitro, they just start with cells, they have no neurons, so it's not an animal," says Auke Ijspeert at the Swiss Federal Institute of Technology at Lausanne. "It's really cells that they manipulate, so I find it maybe the cleanest way."

But are xenobots more like living organisms or traditional robots? "I don't feel any closer to an answer: whether these are robots, whether these are frogs, whether these are something else entirely," says Bongard. ▮

Animal behaviour

Lions use yawns to signal to others that it is time to move

LIONS have contagious yawns, and they seem to use the behaviour to send signals to each other. The observation provides the first concrete evidence that yawning can synchronise behaviour in an animal species.

"Lions share a lot of things, like highly organised hunts," says Elisabetta Palagi at the University of Pisa in Italy. "So obviously they need to synchronise movement."

Palagi had intended to study hyenas. But when her master's students were in South Africa collecting data, they started sending her videos of lions as well. Watching the clips, Palagi couldn't help but notice how the lions kept yawning one after the other and then got up and moved in near synchrony.

She asked her students, Grazia Casetta and Andrea Paolo Nolfo, to focus on 19 lions living in two social groups at Siyafunda Wildlife & Conservation, a research camp within the Greater Makalali Private Game Reserve in Limpopo province, South Africa. They took nearly 5 hours of video per lion, day and night, over a four-month period.

The team found that when a single lion yawned and another lion could see it do so, the second lion started to yawn within 3 minutes of the first. The yawns were so contagious that the likelihood of the second lion yawning within the 3-minute window was 139 times higher than it would have been if the first lion hadn't yawned.

139

times more likely that a lion will yawn soon after it has seen its peer do so

The team also realised that the contagious yawns led to coordinated actions, which usually involved getting up and walking away. The felines were 11 times more likely to synchronise their next moves with the first lion following a spell of contagious yawning (*Animal Behaviour*, doi.org/gjg65w).

Despite this new understanding of lion yawns, classifying the motive behind any individual yawn is still challenging, says Palagi. "It's difficult to categorise the different kinds of yawns because they can all be due to a mix of factors." ▮

Christa Lesté-Lasserre

Animals

Sponges don't get cancer from extreme radiation exposure

Michael Le Page

SPONGES can live for thousands of years, grow continuously and lack an immune system, so they should be particularly prone to cancers. But sponges exposed to X-rays have survived 100 times the lethal dose for humans without tumours.

In fact, sponges have the highest level of radiation resistance ever observed in any animal whose cells keep dividing throughout its lifetime – unlike, say, tardigrades, whose cells stop dividing.

Angelo Fortunato at Arizona State University and his team have been studying animals for which there are no records of cancers, such as sponges, comb jellies and placozoa, to see if they really are cancer resistant and, if so, why.

The researchers exposed young sponges of the species *Tethya wilhelma* to increasing X-ray doses. To their surprise, they found that it took 800 gray of radiation to kill most of the sponges. When they were exposed to 600 gray, they had no obvious signs of cell death (*bioRxiv*, doi.org/f4dp). For comparison, a chest X-ray exposes a person to around 0.1 milligray.

However, at 600 gray, the animals lost their shape and their ability to filter food from the water over the following 20 days or so. The sponges then began reforming and regained their normal structure after around 180 days. This wasn't a big surprise, he says, as sponges are known to be able to reform even if broken apart into single cells.

After a year, none showed any signs of tumours. These animals appear to have very good mechanisms both for preventing DNA damage in the first place and for repairing damage once it occurs. That might be because their water-filtering lifestyle makes them vulnerable to DNA-damaging toxins, so they may have evolved to cope with such damage, says Fortunato. ▮

Interview: Andrew Whiten

Animal culture is widespread

Once thought to be uniquely human, culture is showing up in all sorts of animals, finds **Michael Le Page**

THERE has been "an explosion of discoveries" showing that animal culture is far more widespread and diverse than we imagined, writes Andrew Whiten in a paper published last week that reviews earlier studies on the topic (*Science*, doi.org/gjndw3). *New Scientist* quizzed Whiten about his work.

Michael Le Page: Many readers will know that apes and whales have culture, such as tool use in chimpanzees, but you say that even insects have it.
Andrew Whiten: That is the big surprise. The evidence was really just published in the last few years. So some of us are still reeling from that and thinking, "Well, wow, culture is everywhere." It's the reach of animal culture across an increasing range of species that's one of the main points of my paper.

What exactly do researchers mean by animal culture?
It is basically behaviour that is passed from one individual to another and becomes a group characteristic. It may be passed down many generations.

Profile
Andrew Whiten is a zoologist and psychologist at the University of St Andrews in the UK

Some fish on coral reefs learn foraging routes from their peers

ALEX MUSTARD/NATUREPL

Can you give an example of insect culture?
There's good evidence for what's called mate choice copying in fruit flies. So if female fruit flies watch a male who's been dusted green by experimenters mate with a female, later on, if given a choice, those females will prefer green-dusted males.

The reason that you can talk about cultural transmission is that if other females watch those females mating, they inherit that same bias.

And fish can have culture, too?
Yes, fish have been shown both in the wild on coral reefs and in the lab to learn things like foraging routes socially. A fish will swim with a shoal a particular route. It will learn that route and then, if it's tested by itself, that's the route it follows.

Alongside the loss of biodiversity, are we losing animal cultures before we even know they exist?
Yes. A research group has shown that habitat degradation leads to degradation in the behaviour repertoires of chimpanzees, which we now think of as largely culturally determined. This kind of effect may become more common. However, as we increase our understanding, we may be in a position to reintroduce cultures.

How do we reintroduce animal cultures?
Some birds reared in captivity don't know their migratory pathway. To get them migrating again, they can be taught to follow a microlight aircraft. Another situation is where animals are being reintroduced into the wild. When golden lion tamarins were first released, they had enormous mortality. They did not know what predators to avoid. So now conservationists are trying to give animals back some culture before they're released to the wild.

The United Nations Environment Programme has sponsored workshops recently, developing a number of principles for how what we've learned about animal culture can be built into conservation politics, policies and practices. ▮

To find out more about animal intelligence, turn to page 36

Medical technology

Handheld camera lets cancer surgeons see radioactive cells

Clare Wilson

CANCER surgeons may be able to find sites in the body where tumour cells have spread with a portable camera that detects gamma radiation as well as visible light.

Current gamma imaging is generally done using machines the size of a small room, which can't be moved into an operating theatre.

When cancer cells escape from a tumour, they often end up in the nearest lymph nodes – a network of several hundred glands distributed around the body, each about the size of a baked bean. During cancer removal surgery, doctors often need to also remove the nearest lymph nodes to see if they contain tumour cells. If they don't, the person may be able to avoid further surgery or aggressive cancer treatment.

But lymph nodes can be hard to find, so doctors can inject a slightly radioactive dye that releases gamma radiation near the site of the cancer. The dye drains from the tissue into the nearest lymph nodes. During the operation, surgeons currently locate lymph nodes giving off gamma radiation using a wand-like probe that produces a visual or audio alert like a metal detector, but this can't form images.

That makes it hard to locate the right lymph nodes in a complex area like the neck that is packed with crucial nerves and blood vessels, says Sarah Bugby at Loughborough University in the UK. "It could be beeping and you take out one lymph node, but it could be another lymph node behind it giving the signal."

Bugby's team has developed a handheld device containing two gamma detectors that work like pinhole cameras slightly offset from each other, to create a three-dimensional image of the radiation source (*Physics in Medicine & Biology*, doi.org/f4dc). This is overlaid on an ordinary optical image to help surgeons pinpoint the radiation source within the body. ▮

Energy

Two UK firms make steps towards clean fusion power

Adam Vaughan

FIRST LIGHT FUSION

First Light Fusion is building a "gun" to achieve fusion

TWO UK companies leading efforts to reproduce the way the sun makes energy are both on the path to hitting significant milestones in their attempts to commercialise nuclear fusion by the 2030s.

On 25 March, Oxfordshire-based Tokamak Energy made its first plasma – the state hydrogen reaches when heated to extreme temperatures – after a £25 million upgrade to its tokamak, the machines used to create fusion reactions.

Meanwhile, First Light Fusion, also in Oxfordshire, has entered the final days of building a new 22-metre-long "gun" for use in what it calls "projectile fusion".

The two companies are among 24 private firms worldwide trying to crack the challenge of getting more energy out of a fusion reactor than goes in – and commercialise the technology fast enough to provide a steady source of low-carbon power to tackle climate change.

Most fusion research, from JET in the UK to the ITER project being built in southern France, is undertaken with billions of pounds' worth of public funding through countries' joint efforts.

David Kingham at Tokamak Energy says nuclear fusion firms typically have a different approach to that of these public efforts. "The private sector brings this focus on innovation and rapid development of prototypes and devices," he says. "Government laboratories tend to be very keen on the science and scientific understanding of the plasmas. It sets a different pace of things."

> "The private sector brings this focus on innovation and rapid development of devices"

Both Tokamak Energy and First Light Fusion have ambitious targets to have a first fusion power station running in the 2030s. By comparison, the UK government's goal is to have one by 2040, while one spun off from ITER isn't planned until the second half of the century – too late to contribute to current efforts to halt global warming.

Tokamak Energy's upgraded spherical tokamak includes a new device to better handle the heat from making a plasma. The upgrade also allows the copper magnets that control the plasma to be cooled with liquid nitrogen, meaning more current can be run to generate a stronger magnetic field. That will be crucial to jump from the 15 million °C plasma the firm has achieved so far, to the 100 million °C one it hopes to create later this year.

Nick Hawker at First Light Fusion is taking a very different tack. The company is using a new method that it hopes will be an affordable way to solve so-called inertial confinement fusion, which generates huge pressure to compress hydrogen fuel and start fusion.

For the past two years, the firm has operated a machine that launches projectiles flying at 20 kilometres a second at a target using electromagnetic force. Its new device, housed in an armoured bunker dubbed the Citadel, is a 25-tonne "big gun" that uses gunpowder and hydrogen gas to launch larger but slower projectiles at about 6.5 kilometres per second.

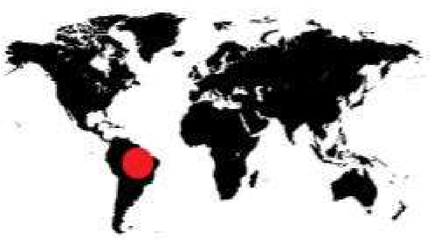
It remains unclear whether inertial confinement fusion will ever work. The National Ignition Facility in California, a huge laser and the world's biggest experiment of this kind, has struggled since completion in 2009, being beset by problems that computer models hadn't thrown up.

First Light Fusion's gun costs about £1 million to make, while the National Ignition Facility cost the equivalent of several billion pounds, although it delivers far higher power. As Hawker says: "We definitely have a cheaper way. The question is – can we make it work?" ▮

Evolution

Stingray mystery solved

The Amazon's stingrays were stranded by the Caribbean Sea



Jake Buehler

THE waterways draining out of tropical regions of South America are home to dozens of species of freshwater stingrays. The fish evolved from seagoing ancestors, but exactly how they got inland has been unclear. Now it seems they were carried by the Caribbean Sea reaching deep into the continent millions of years ago.

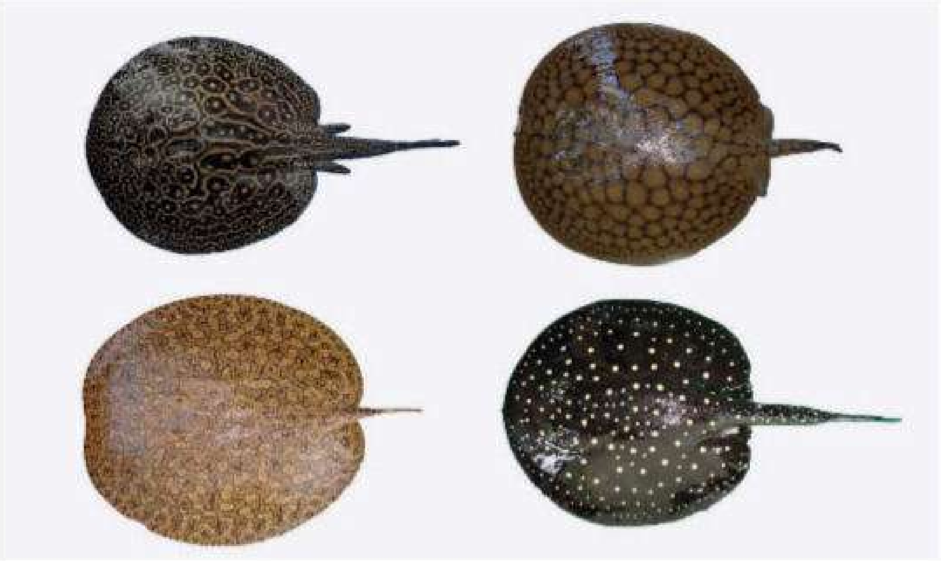
Central and South America are home to about 20 per cent of the world's total fish species, says João Pedro Fontenelle at the University of Toronto in Canada. Intrigued by this biodiversity, Fontenelle and his colleagues looked at the evolutionary history of river stingrays, which are only found in South America. There are 38 species, most with spots or marble patterns, and they range in size from 25 centimetres to more than a metre across. The stingrays are also the only exclusively freshwater lineage of shark or ray alive today.

The researchers analysed DNA from 350 individual stingrays across 35 different species. By comparing genetic differences, they figured out how the stingrays split into many species over time, giving insight into where and when they first left the sea.

Fontenelle and his team estimate that the river stingrays diverged from their ocean relatives around 26 million years ago, between the Oligocene and Miocene epochs, in the upper Amazon basin.

"The sea level was higher than it is today and the Andes were not that high, and we had a nice lowland formation on the western portion of the Amazon," says Fontenelle. "That allowed for the sea to come into the continent."

There are 38 species of river stingray in South America



FERNANDO MARQUES

Fossil and chemical evidence in rock suggests the north-western corner of South America was dominated by a vast, swampy sea for millions of years, known as the Pebas wetlands. Its mix of fresh water and saltwater probably varied between locations, says Fontenelle, adding that these complex salt gradients may have allowed the stingrays that were washed in by the sea to gradually adapt to fresh water.

Researchers had wondered whether the stingrays accessed the rivers via an ocean inundation, but such swamping had happened multiple times over tens of millions of years from different ocean basins, so it wasn't clear which iteration of this inland sea marked the stingrays' freshwater debut. The new research helps confirm the stingrays' Pebas origins and pinpoints the timing (*Journal of Biogeography*, doi.org/f4b8).

"It's kind of like building a jigsaw puzzle," says Fontenelle. "We're getting clues from our organisms, from geology and computer simulations, and [with] all of that together, we try to tell a story."

Andrea Thomaz at Del Rosario University in Bogotá, Colombia, says she is surprised at how well the genetic data aligns with landscape changes in the Amazon basin. "South America is such a diverse continent in terms of biodiversity and geological processes that studies like this are of great importance to understand how the fauna responded similarly or not to geological events." ▮

Technology

Robot guide dog could help people who are blind

GUIDE dogs offer social, physical and mental benefits for some people who are blind, but training them is a costly and lengthy process, so researchers have created a robotic alternative.

Zhongyu Li at the University of California, Berkeley, and his colleagues programmed a four-legged, dog-like robot to safely guide people with a lead.

The researchers equipped an existing robot with a laser-ranging system to create an accurate map of its surroundings and a rotating camera that remains pointed at the person the robot is guiding, to determine their relative position.

Once given a start point and an end point, the robot's software generates a simple route with waypoints. It then calculates its movements on the go depending on obstacles and the behaviour of the person it is leading.

Rather than constantly pulling away, keeping the lead taut, the robot is programmed to let its lead go slack when turning in a confined space. This allows the robot to more precisely control the path that the person being guided takes (arxiv.org/abs/2103.14300).

Unlike real guide dogs, which have to be trained individually, robot guide dog training is scalable, says Li. "Using a robotic guide dog, we can directly deploy our code from one robot to another. As time goes by and the hardware becomes more affordable, we can actually use this kind of dog to help, to serve, humans," he says.

"As the hardware becomes more affordable, we can actually use such robotic dogs to help humans"

Tim Stafford at UK charity Guide Dogs says he supports the idea of robotic guides if it helps people with sight loss lead independent lives.

"That being said, guide dog owners will frequently speak about their dog's impact on their own life and well-being," he says. "They value their dog as a partner, companion and family member, as well as a guide dog. It is this deep bond which makes the relationship unique and so much more than just a way to get around safely." ▮

Matthew Sparkes

ANDREY MOISSEYEV/ALAMY

Weather

Sydney's suburbs are hotter than the coast in heatwaves

WEATHER patterns and urban overheating are interacting to make Sydney's inland suburbs up to 10°C warmer than coastal areas during extreme heat events.

Urban overheating occurs when temperatures in parts of an urban environment are higher than those in surrounding urban areas. It is a result of a number of factors, including heat fluxes linked to human activity and air pollution. What's more, artificial materials used to build urban architecture absorb solar radiation and release it slowly, further heating the air.

Hassan Khan at the University of New South Wales in Sydney and his colleagues have analysed how large weather patterns interact with urban overheating in Sydney.

They looked at temperatures in the Sydney central business district (CBD), which is close to the ocean, and compared them with locations in inner Sydney – between 8 and 12 kilometres inland – and in western Sydney, between 25 and 50 kilometres inland.

The researchers found that during extreme heat events, the mean daily maximum temperature was between 8 and 10.5°C hotter in western Sydney than in the CBD, despite the fact that the CBD is more built-up than western Sydney. In inner Sydney suburbs, the mean maximum was 5 to 6.5°C hotter than in the CBD (*Scientific Reports*, doi.org/f4fr).

One reason for the difference could be that coastal winds help cool the CBD, but they aren't able to penetrate inland to reach inner and western Sydney. **Donna Lu**

Astrophysics

Radiation blasts hint at mid-sized black hole

BLASTS of radiation from distant galaxies have revealed signs of an elusive medium-sized black hole. If so, it may be a link between the small black holes that we have observed and the supermassive black holes that sit at the centres of galaxies. These medium-sized objects are hard to find because material around them doesn't shine brightly, like with supermassive black holes, and they are too big for gravitational-wave detectors to spot.

Rachel Webster at the University of Melbourne in Australia and her colleagues spotted this cosmic middleweight by examining data on about 2700 gamma-ray bursts: extraordinarily bright flashes of radiation thought to come from explosions in other galaxies. They searched for evidence of gravitational lensing, which occurs when a massive, dense object stretches light around it.

The researchers found only one example of gravitational lensing, in which the light from the gamma-ray burst was warped by an object about 55,000 times as massive as the sun (*Nature Astronomy*, doi.org/f4cz).

An object that massive yet dim is probably a black hole – and if that is the case, it is far smaller than the smallest supermassive black hole we have ever seen and far larger than the largest "normal" one.

Objects like this may help bridge the gap between small black holes and extremely large ones. "We've got these small black holes and we've got these supermassive black holes, but in the middle was nothing," says James Paynter at the University of Melbourne, part of the research team.

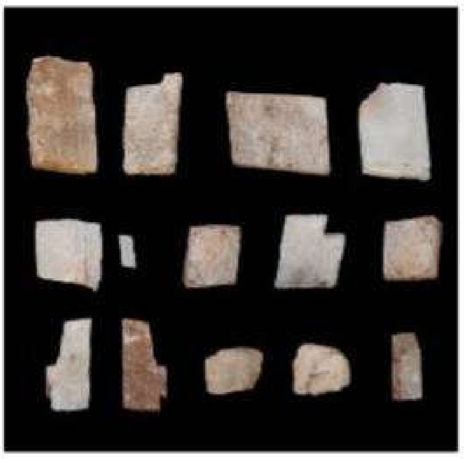
Studying these objects could help us figure out how supermassive black holes form, a major mystery in astrophysics.
Leah Crane

Humans

Ancient people collected crystals

A CACHE of beautiful crystals collected 105,000 years ago in South Africa is shedding new light on the emergence of complex behaviours in our species.

A team led by Jayne Wilkins at Griffith University, Australia, discovered 22 distinctively shaped white calcite crystals at a site in the Kalahari desert called Ga-Mohana Hill North Rockshelter. "They are little rhomboids, really visually striking," says Wilkins.



JAYNE WILKINS

These geometric crystals didn't originate at the site and haven't been modified, so seem to have been collected and brought to the rock shelter for ornamental purposes (*Nature*, doi.org/f4c2). "They don't seem to have been used for everyday tasks," she says.

The collection of beautiful items might seem normal for humans today, but the behaviour only emerged around 100,000 years ago. "Collecting these kinds of pretty objects for non-utilitarian reasons could have its roots in symbolism and arts and culture," says Wilkins.

These discoveries in the Kalahari, 600 kilometres from the sea, are challenging the prevailing assumption that the emergence of complex behaviours like symbolism and technological innovation emerged at the coast, where humans had access to seafood containing nutrients thought to support brain growth. **Alison George**

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Really brief

CALOGERO SANTORO & JOSÉ CAPRILES

Parrot trade in the Atacama desert

An oasis in Chile's Atacama desert once served as a hub for the trade of live parrots across the Andes. The remains of birds and feathers at the site show that some parrots were transported more than 500 kilometres. The trade occurred between AD 1450 and 1100 (*PNAS*, doi.org/f365).

Pesticide toxicity to pollinators is rising

Bees and other pollinators in the US have been exposed to growing levels of toxicity from pesticides over 25 years, despite falls in the amount used. It may be because farmers now use chemicals that are less toxic to mammals and birds but more toxic to insects (*Science*, DOI: 10.1126/science.abe1148).

Ancient British sea salt production

The people living at a coastal site in what is now north-east England 5500 years ago were heating seawater to extract salt, according to archaeologists working at the site. The discovery means ancient Britons were extracting sea salt 2000 years earlier than we had thought (*Antiquity*, doi.org/f4cg).

Particle physics

Antimatter atoms cooled with lasers

FOR the first time, one of our most precise mechanisms for controlling matter has been applied to antimatter atoms, slowing them down for measurement.

Antimatter particles have the same mass as particles of ordinary matter, but the opposite charge. An antihydrogen atom, for example, is made of an antiproton and a positron, the antimatter equivalent of an electron.

Makoto Fujiwara at TRIUMF, Canada's national particle accelerator centre, and his colleagues used the ALPHA-2 experiment at the CERN particle physics lab near Geneva, Switzerland, to create clouds of about 1000 antihydrogen atoms in a magnetic trap.

The team used a laser to shoot particles of light called photons at the right wavelength to slow down any anti-atoms that were moving directly towards the laser. "It's kind of like we're shooting a tiny ball at the atom, and the ball is very small, so the slowing down in this collision is very small, but we do it many times," says Fujiwara.

The group managed to slow the anti-atoms by more than a factor of 10. Laser cooling is often used to measure energy transitions – the movement of electrons to different energy levels – in atoms. For cooled antihydrogen atoms, the team's measurement of this was nearly three times as precise as it was with uncooled anti-atoms (*Nature*, doi.org/f4c4).

Such measurements could let us see any tiny differences in the behaviour of matter and antimatter. **Leah Crane**

Psychology

ALEX DODD, CAMERASPORT VIA GETTY IMAGES

Football teams still get home advantage in empty stadiums

FOOTBALL teams seem to retain an advantage over opponents when playing at home even when there are no fans in the stadium.

Historical analysis of European football leagues shows that the home team wins around 50 per cent of matches, with the chance of a draw or home defeat both being about 25 per cent. This home advantage has been theorised to be caused by the roar from the crowd motivating home players and pressuring referees to give decisions that favour the home team.

Daniel Memmert at the German Sport University Cologne and his colleagues looked at data from 40,000 men's football matches in Europe before and after coronavirus restrictions led to the banning of fans from sports events.

During lockdown, referees gave fewer yellow and red cards to away teams than in games played in front of fans. But the proportion of away teams winning matches played without fans increased by just 7 percentage points, which Memmert says isn't statistically significant (*PLoS One*, doi.org/f4fs).

Territorial behaviour could be a factor for home advantage, says Memmert, comparing it to children being more outgoing in their own homes. Chris Stokel-Walker

Robotics

Robot lizard climbs wall like the real thing

A ROBOT made to mimic the movements of lizards has shown how the rotation of their legs and the speed at which they move helps them climb.

Christofer Clemente at the University of the Sunshine Coast, Australia, and his team built a 24-centimetre-long robot and programmed its legs and feet to mimic the gait of climbing lizards.

They pitted it against common house geckos and Australian water dragons, filming them all as they climbed a carpeted wall.

The researchers found that the best way to increase the distance climbed was to take a Goldilocks approach: not too fast and not too slow. The robot stayed on the wall better when climbing at between 40 and 70 per cent of its maximum speed and the lizards when going at 60 to 80 per cent of theirs (*Proceedings of the Royal Society B*, doi.org/f4dd).

The robot was also better at staying on the wall when its limbs were rotated inwards or outwards and could climb the furthest when combining limb movements with a side-to-side spine motion, much as some lizards do. Clemente says this knowledge could help us build better climbing machines.
Ibrahim Sawal

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“2021 must be the year to reconcile humanity with nature”

António Guterres,
United Nations Secretary General, Paris, December 2020

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CERN and Mont Blanc: Dark and frozen matter

One of the world's most important centres of science and innovation, Geneva is also a charming lakeside town with a fascinating history. The tour focuses on CERN, where they operate the famous Large Hadron Collider, and Mont Blanc to investigate receding glaciers and what they reveal about history. Accompanied by particle physicist Darren Price and science journalist Laura Spinney.

During your stay in Geneva you will also explore the old town, visit the Museum of the History of Science, and learn about watchmaking at an historic workshop.

Highlights

- Tour of the CERN complex. Gain an insight into the work which takes place here including a visit to the lab itself where you will see the Universe of Particles exhibition inside the Globe of Science and Innovation – a 27 metre high wooden dome – as well as the Microcosm exhibition, which displays a range of interactive exhibits including a model section of the Large Hadron Collider, and a simulation of a particle accelerator.

- Evening talk and walking seminar around CERN from Dr Darren Price on particle physics and his work at CERN.

- A walking tour of the old town centre of Geneva, including the Cathedral where John Calvin preached in the 16th century, and a visit to a traditional watchmaker where you will learn more about one of the city's most famous crafts.

- Walking seminars when visiting Chamonix and Montblanc plus an evening talk from science journalist Laura Spinney.

- Visit the charming small town of Chamonix-Mont-Blanc and take the mountain railway to the Mer de Glace where you will visit an ice cave carved into the glacier itself, and enjoy a traditional fondue lunch.

- Cable car up to the summit of the Aiguille du Midi. At over 3,800 metres you will have stunning views over the Alps.

- Visit the Museum of the History of Science, which houses exhibits relating to astronomy, microscopy, meteorology and electricity.

- Explore the Palais des Nations, the rare medicinal plants of the Botanical Gardens and enjoy a cruise of Lake Geneva.

Covid-19 safety protocol includes:

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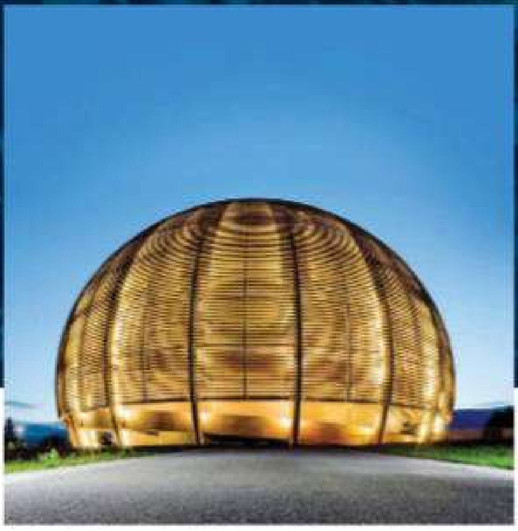

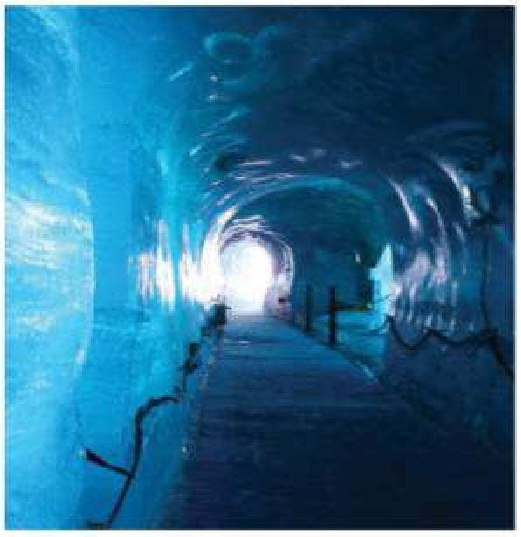

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Jacob Aron on his favourite time travel video games **p34**

Comment

Floundering on forests

Global tree loss is undermining tactics to address the climate crisis. It is time world leaders got their act together, says **Adam Vaughan**

Adam Vaughan is chief reporter at *New Scientist*

MICHELLE D'URBANO

WORLD leaders love to present trees as the answer to our climate change woes. Earth has room for another 0.9 billion hectares of them, which could buy us an extra 20 years to decarbonise our societies by locking up emitted carbon. But many countries are terrible at even holding on to their existing carbon-rich trees.

Satellite images show the world lost 4.2 million hectares of undisturbed rainforest last year, up 12 per cent on 2019, according to the US non-profit World Resources Institute (WRI) and Global Forest Watch. Losses in the tropics have now increased for two years in a row, driven mostly by forest clearance for agriculture.

However, this problem isn't caused solely by lower-income countries, as a recent study published in *Nature Ecology & Evolution* made clear by linking deforestation to international trade. High-income countries, like the UK, Japan and Germany, are driving deforestation abroad with their demand for beef, soya, palm oil and other goods.

Last year's increase in tree cover loss, which includes deforestation as well as natural losses, such as through fire, is especially galling because 2020 was the deadline a host of countries and businesses set for halving deforestation from 2014 levels. The timing also poses a headache for the United Nations and those hoping for a good outcome at this year's COP26 climate summit in November. Patricia Espinosa, the executive secretary of the UN Framework Convention on Climate Change, says a "really critical" factor in the summit's success will be high-income countries delivering on their promises of sending $100 billion a year of climate finance to lower-income ones.

But alarming deforestation trends in Brazil under President Jair Bolsonaro saw Norway and Germany halt funds to Brazil for protecting the Amazon rainforest in 2019. The situation is no better today, with Brazil losing 1.7 million hectares in 2020, three times that of the country with the next biggest losses, the Democratic Republic of the Congo. Moreover, Brazil's increase in loss was more than twice the global average, at 25 per cent. Boosting climate aid to Brazil in that context poses a tricky conundrum for high-income countries.

These rates of tree cover loss have a huge climate impact. Mikaela Weisse at the WRI and her colleagues estimate last year's loss released about 2.6 billion tonnes of carbon dioxide, roughly on a par with India, the world's fourth biggest emitter. Continuing with such colossal emissions will wipe out the amount of CO_2 that tree-planting is expected to absorb.

It is time for world leaders to get a grip. If we are to stand any chance of meeting the world's climate goals, governments must take deforestation as seriously as they do transforming their energy systems. That must start at COP26.

The UK's preferred approach is a "dialogue" it launched in February, for firms and countries to work out how international trade can protect, rather than demolish, rainforests. But as individuals, we don't have to wait for dialogues to bear fruit. Much forest destruction is driven by demand for meat and dairy (the Amazon's big deforestation driver is beef). So while chief executives and heads of state hash things out, you can make a difference now by eating less meat and dairy.

Politics can make stopping deforestation hard. The European Commission and UK government are considering using trade deals and regulations to apply pressure on countries such as Brazil to curb deforestation. However, this may not be viewed well by Brazil.

Weisse says a better approach would be sending funds directly to existing organisations fighting deforestation in Brazil.

Globally, there is hope. Forest loss fell in Indonesia and Malaysia last year – signs that government policies to curb deforestation can work. ▮

No planet B

Moral hazard of vaccination

We are starting to vaccinate our way out of the pandemic, but we shouldn't let that make us complacent about the underlying problems, writes **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *This Book Could Save Your Life*. You can follow him @grahamlawton

Graham's week

What I'm reading

I have built up a stack of unread issues of New Scientist *– must get onto them.*

What I'm watching

Taskmaster *is back on. Pure, joyous daftness.*

What I'm working on

I'm trying to clean up my pension fund, which turns out to be a climate disaster.

This column appears monthly. Up next week: Annalee Newitz

I RECEIVED the first dose of my covid-19 vaccine a couple of weeks ago, and it felt like a moment of liberation. By coincidence, it went into my arm on the anniversary of the announcement of the UK's first national lockdown. As I write, we are eagerly anticipating the gradual lifting of the third such lockdown and the return of some freedoms: a walk with friends, a drink in the pub, a swim in a lido.

The UK's well-organised vaccine roll-out has played a huge part in bringing us to this point and we are indebted to the National Health Service – although unlike many of my fellow citizens, I am not prepared to forgive and forget the catalogue of inept and costly government decisions that necessitated a third lockdown in the first place.

That aside, I am relieved to be brewing up my first batch of antibodies against the SARS-CoV-2 coronavirus (I assume that my sore arm and throbbing head were signs that my immune system was busy doing that). I also hope everyone who wants to be gets vaccinated soon. But at the same time, I am slightly alarmed at one of the unintended consequences of a hopefully successful global vaccination programme.

The source of my alarm is something called moral hazard, which is a familiar concept in the world of climate change. This is the idea that well-intentioned attempts to reduce risk can create perverse incentives to take greater risks. For example, a person who is insured against house fires may be less careful with matches, knowing that if the worst happens the insurance company will pick up the pieces.

Don't get me wrong: I am wholly in favour of covid-19 vaccination. It is the only viable exit strategy from the pandemic and, despite the feverish fantasies of some self-appointed covid-19 sceptics, environmentalists like me don't wish for perpetual lockdown. So bear with me.

In climate circles, moral hazard usually comes up in connection with get-out-of-jail-free tech such as geoengineering. If we create a backstop on global warming by, say, pumping sulphur dioxide into the stratosphere, what is the incentive for radically reducing greenhouse gas emissions or reinventing our energy systems? The hazard is that we procrastinate and overshoot, leaving ourselves wholly dependent on pumping ever more sulphur dioxide into the stratosphere while the ocean acidifies beyond rescue.

> "We need to prevent more genies escaping from more bottles, not just rely on anti-genie gene technology"

Moral hazard is also an issue in medicine. For example, some research links the rise in obesity to advances in treatments for heart disease and diabetes. Ditto vaccination: the HPV vaccine, for instance, has been blamed for increases in teenage pregnancy as teens who have had it may be more likely to take risks, safe in the knowledge that they are (probably) immune to a sexually transmitted virus that causes genital cancer.

As yet, however, I haven't seen these dots being joined together in a discussion of the moral hazard of immunisation against covid-19. So, at risk of being curmudgeonly, I would like to start that debate.

There is little doubt that SARS-CoV-2 arose as a direct result of human encroachment on nature. The most likely source is a wild bat in China or nearby. How and where it jumped into humans remains unknown, but the wildlife trade is a prime suspect.

The moral hazard is clear. If we can shield ourselves from the consequences with a vaccine, what incentive do we have to fix our dysfunctional relationship with the natural world? The news that work has begun on universal vaccines that can protect us against any future coronaviruses only exacerbates that hazard.

What we really need is a recalibration of the relationship between humans, the natural environment and non-human animals. This is the basis of One Health, an emerging field built on recognition that the well-being of humans, the natural world and animals are one and the same.

This is no longer a nice-to-have, it is a must-have. The non-profit research organisation EcoHealth Alliance has proposed that protection from diseases lurking in animals should be seen as one of the vital services that intact nature rewards us with. If we look after nature, it will reciprocate. If we don't, it will retaliate.

Let me reiterate: I am not arguing against vaccines. The covid-19 genie is out of the bottle and we must face the consequences. What I am arguing is that we need to prevent more genies escaping from more bottles, not just rely on anti-genie gene technology.

Yes, we are about to vaccinate our way out of the worst global health crisis of a generation. By all means let us create a universal coronavirus vaccine and celebrate it as a triumph. But let's beware the moral hazard of doing so, lest we trap ourselves in a downward spiral of environmental destruction from which there is no technological get-out. ▮

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Partha Dasgupta

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Susan Gardner

Ocean conservationist and director of the Ecosystems Division, UNEP

Cristián Samper

Tropical biologist, president and CEO of the Wildlife Conservation Society

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Zac Goldsmith

Minister for Pacific and the Environment

Foreign, Commonwealth & Development Office (FCDO) and the Department for Environment, Food and Rural Affairs (Defra)

Editor's pick

Taking a new view on quantum reality to task

13 March, p 36

From Mike Bell, Woolacombe, Devon, UK

Carlo Rovelli states that quantum objects have no reality when they aren't interacting with other objects. How do quantum objects not interact gravitationally with other things?

Perhaps quantum objects are always real; it is just difficult to observe their gravitational effects. What's more, given the long wavelength of the photons that make up the cosmic microwave background (CMB), a quantum object in space would find it difficult not to be interacting simultaneously with many CMB photons.

From Brian Reffin Smith, Berlin, Germany

Rovelli mentions the elegance of quantum theory without the usual wave function that it incorporates. He mentions an equation that was added to classical physics and that supports his take on quantum theory: $xp - px = i\hbar$, where x is the position and p is the momentum of the system, with the result depending on the order in which you multiply these terms, and where i is the square root of -1 and $\hbar$ is the Planck constant.

If this is rearranged to give $\hbar = (xp - px)/i$, the Planck constant is then an illogicality divided by an impossibility. This says it all.

From David Brown, Upper Coomera, Queensland, Australia

Rovelli seems to claim that nothing truly exists, except in relation to other things. He is, I believe, attempting to provide a way of dealing with currently unanswerable questions arising from our observations at the quantum level, by saying that if there is no interaction with an object, the object doesn't exist.

If the accepted definition of the word "exist" is used, this means that if an interaction occurs, the object of that interaction is created by the interaction. But where does the energy come from? Where does the information to build the object come from? I think that the use of the word "exist" in this context is misleading. What is needed is a word that reflects the state of the object as "unknown".

From Ray Sheldon, Bridgetown, Nova Scotia, Canada

If we assume that the chair on the cover of the issue featuring Rovelli's article doesn't exist, then we must also assume that he doesn't exist. If this is the case, then who wrote the article?

We aren't immune to tsunamis in the UK

13 March, p 18

From Steven King, Crewkerne, Somerset, UK

Further to the look at the decade since the Fukushima nuclear accident. The UK government has commissioned nuclear plants at Hinkley Point, Bradwell and Sizewell, all on the coast and thus vulnerable to tsunamis.

This is no idle speculation. Research published in 2001 found that volcanic activity on the Atlantic island of La Palma left a fracture that could break, resulting in a large landslide into the sea that could cause a major tsunami. In a few hours, these waves would strike the English coast, with the possibility of three Fukushimas in one day.

Blowing hot and cold over Carney's climate thinking

20 March, p 44

From Catherine Dawson, Devizes, Wiltshire, UK

I was pleased to see the brilliant interview with Mark Carney. I wish he was still governor of the Bank of England, as he could perhaps persuade the UK government that we need a better carbon-pricing mechanism, like the carbon fee and dividend policy of Canada.

This involves introducing an escalating fee on fossil fuels soon after they have been extracted. The funds raised are then redistributed to the population. Business competitiveness issues are mitigated by imposing import fees on competitor products entering the country and through rebates to exporting businesses.

A well-designed scheme could have social and environmental benefits, distributing the revenues equitably and stimulating investment in low-carbon technologies.

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

I was disappointed with the interview with Carney, though I suppose I shouldn't have been; after all, this was a capitalist offering capitalist solutions to numerous capitalist problems, of which climate change was but one.

The piece contained a number of concepts meant to address climate change that contributors to *New Scientist*, both staff members and occasional writers, have debunked over the years, such as carbon trading and the oxymoron of "sustainable growth".

Capitalism is about return on investment, which can only come about by growth, and continual, perpetual growth is globally impossible.

In this neck of the woods, friendship is long-distance

6 March, p 36

From Jon Hinwood, Melbourne, Australia

Among other interesting facts that Robin Dunbar mentioned in his look at the science of friendship is that people were unwilling to spend more than 30 minutes travelling to see a friend.

Were the population samples on which this claim is based drawn from a university campus or inner-city areas? That certainly wouldn't apply in rural Australia. Perhaps it is related to the travel time required for other activities, such as work or shopping, and isn't a universal constant.

If you tell yourself you are younger, you may feel it

20 March, p 36

From Allan Smith, London, UK

Your article suggests that biological age can be influenced by your state of mind. I agree that a positive outlook is beneficial, but would add that autosuggestion can also be useful. When I turned 70, I decided I would rather be 35. I now think of myself as 35, and feel much happier as a consequence.

From Richard Mellish, London, UK

You report strong evidence of a correlation between mental attitude and biological age, but is there any evidence of causality? Causality in the other direction is plausible: if your physical and mental fitness is good, you are likely to feel younger, and the converse likewise.

Spring has sprung a long time before the equinox

20 March, p 51

From Conrad Jones, Cynwyl Elfed, Carmarthenshire, UK

Abigail Beall gave us a clear, logical explanation as to why day and night aren't of equal length at the equinox. What seems illogical to me, though, is why spring and autumn start at the equinox – and, even more oddly, that the summer solstice is called midsummer's day and the winter solstice midwinter.

Spring started for me on 3 February, evidenced by leaf buds being visible, catkins being out and birds starting to pair. Based on a 13-week seasonal period, for me, spring will end on 4 May.

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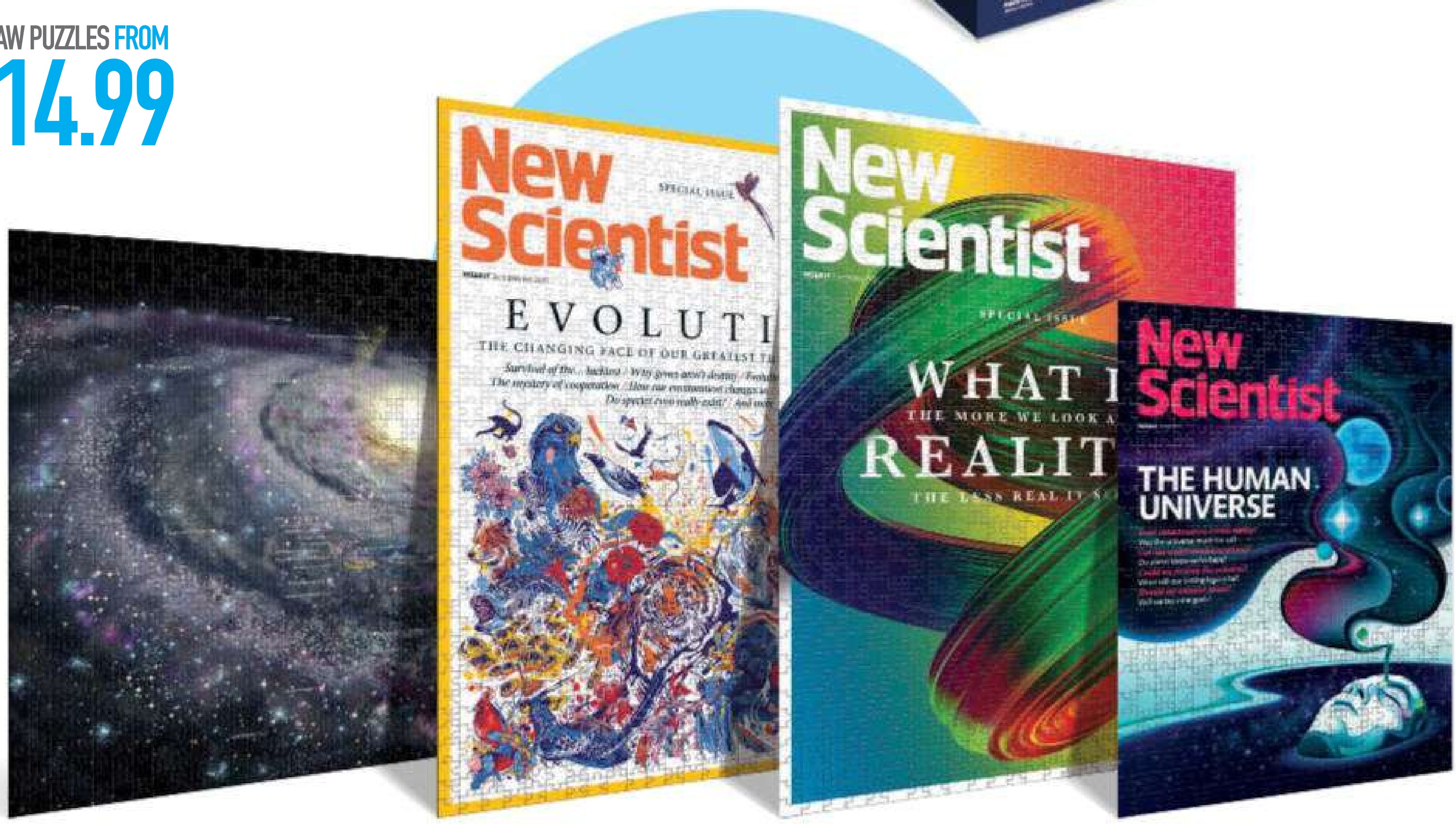

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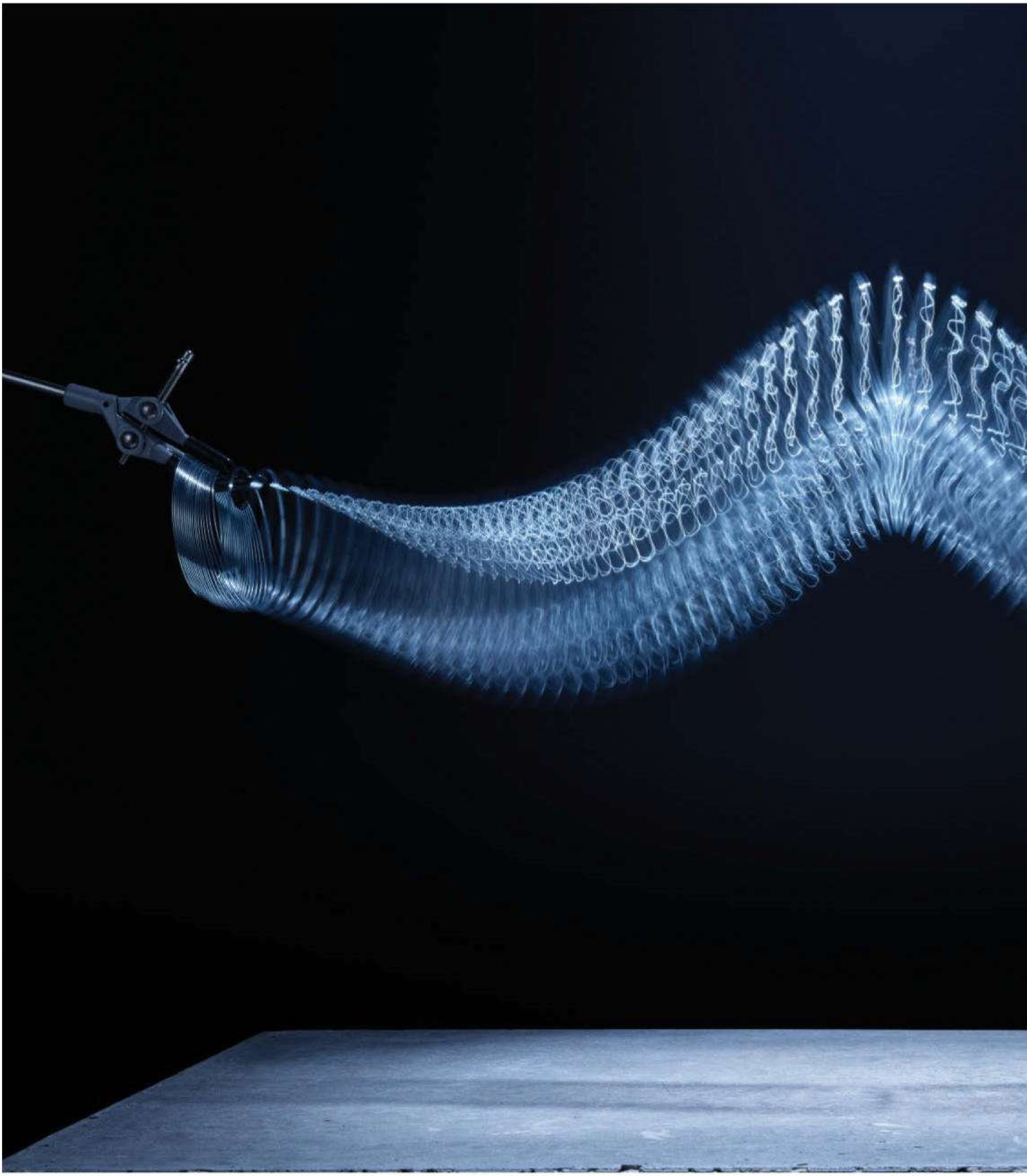
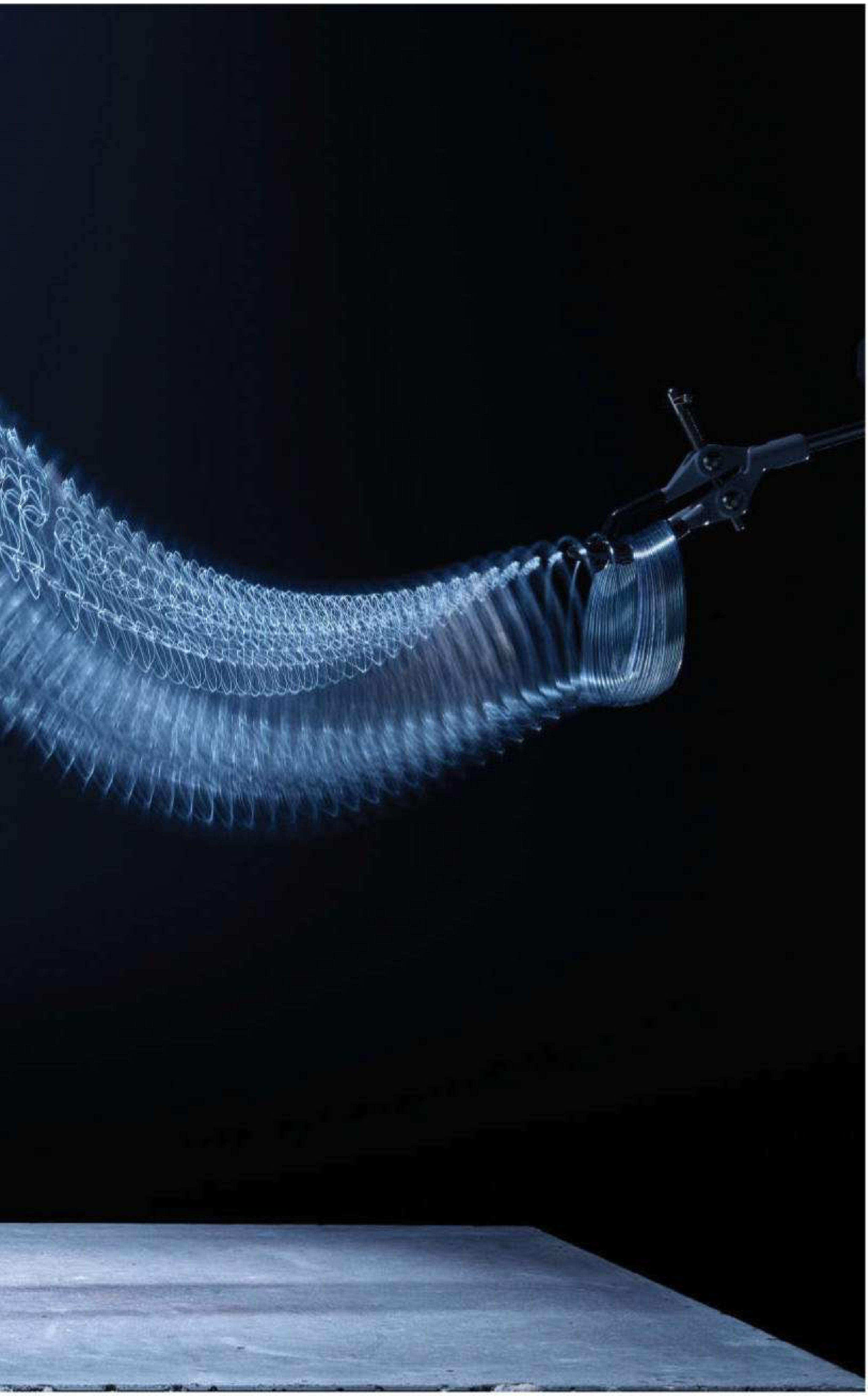




Measuring up

Photographer Greg White

MODERN, minimal and oddly mesmerising, this image and the ones overleaf offer a fresh interpretation of fundamental standards of measurement in physics. The shots are part of photographer Greg White's collection *Base Quantities.*

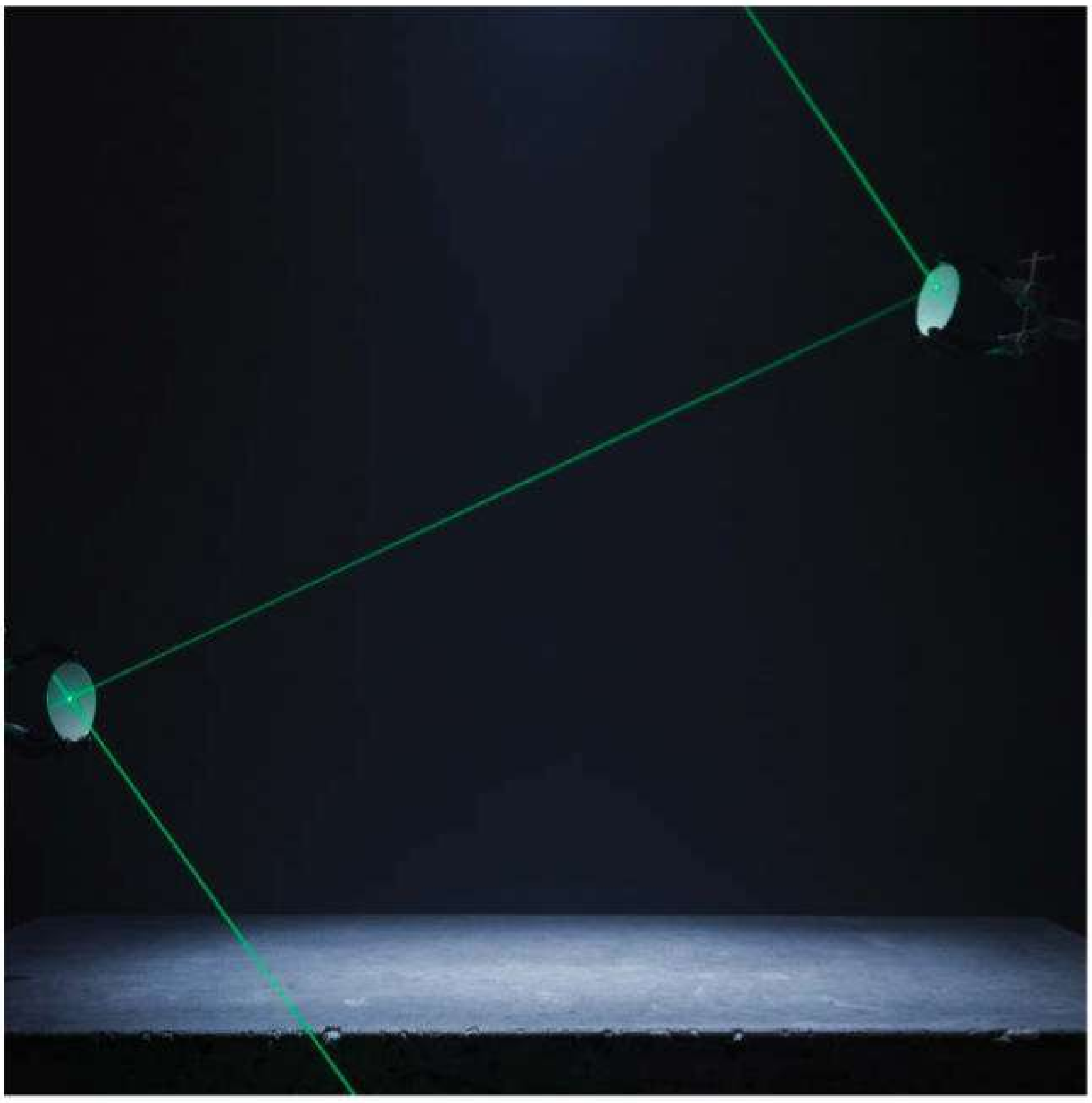
According to the International System of Quantities (ISQ), a base quantity is a physical quantity that can't be defined or expressed in terms of other quantities. The ISQ has defined seven base quantities as follows, with their SI base units and symbols in brackets: time (second, s); mass (kilogram, kg); length (metre, m); temperature (kelvin, K); amount of substance (mole, mol); electric current (ampere, A); and luminous intensity (candela, cd).

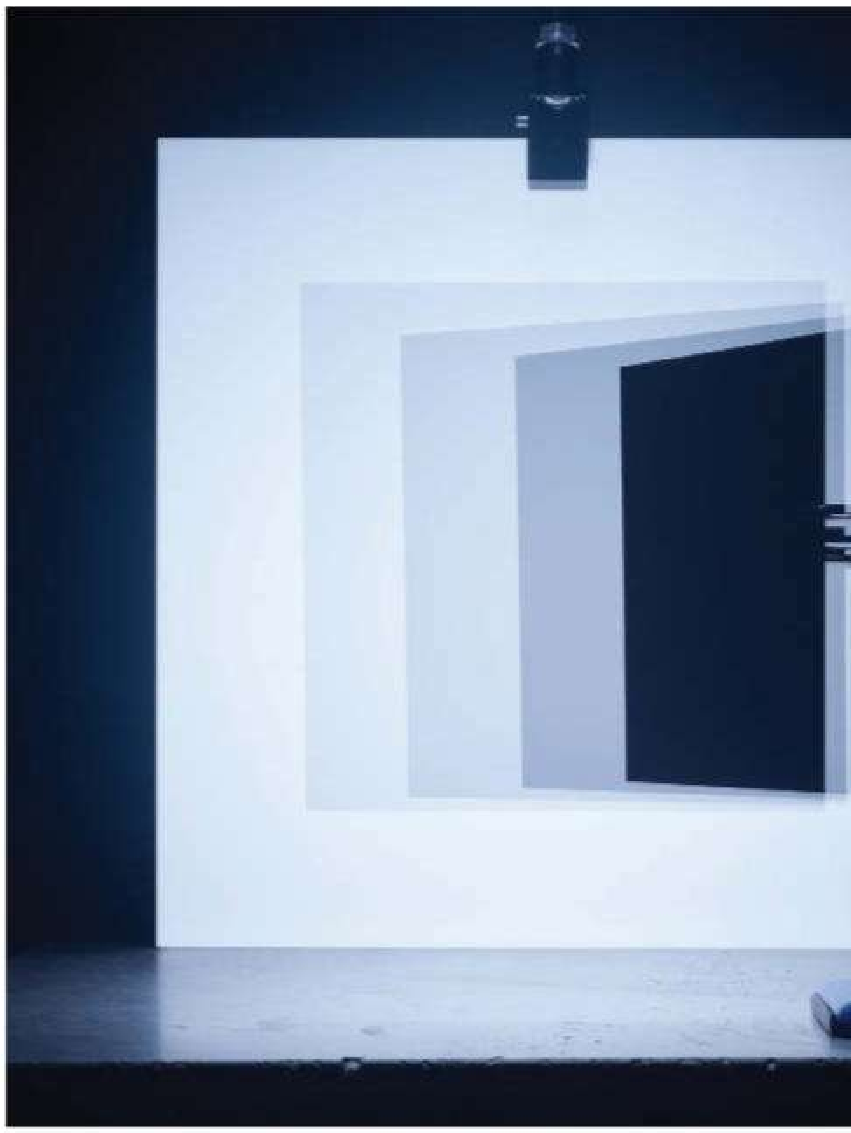
Each base quantity was captured using simple props and smart camera techniques, including multiple exposures. White says he wanted to visually interpret an aspect of science, but found they were all too specific except for the ISQ's base quantities, which he thought would make an interesting series.

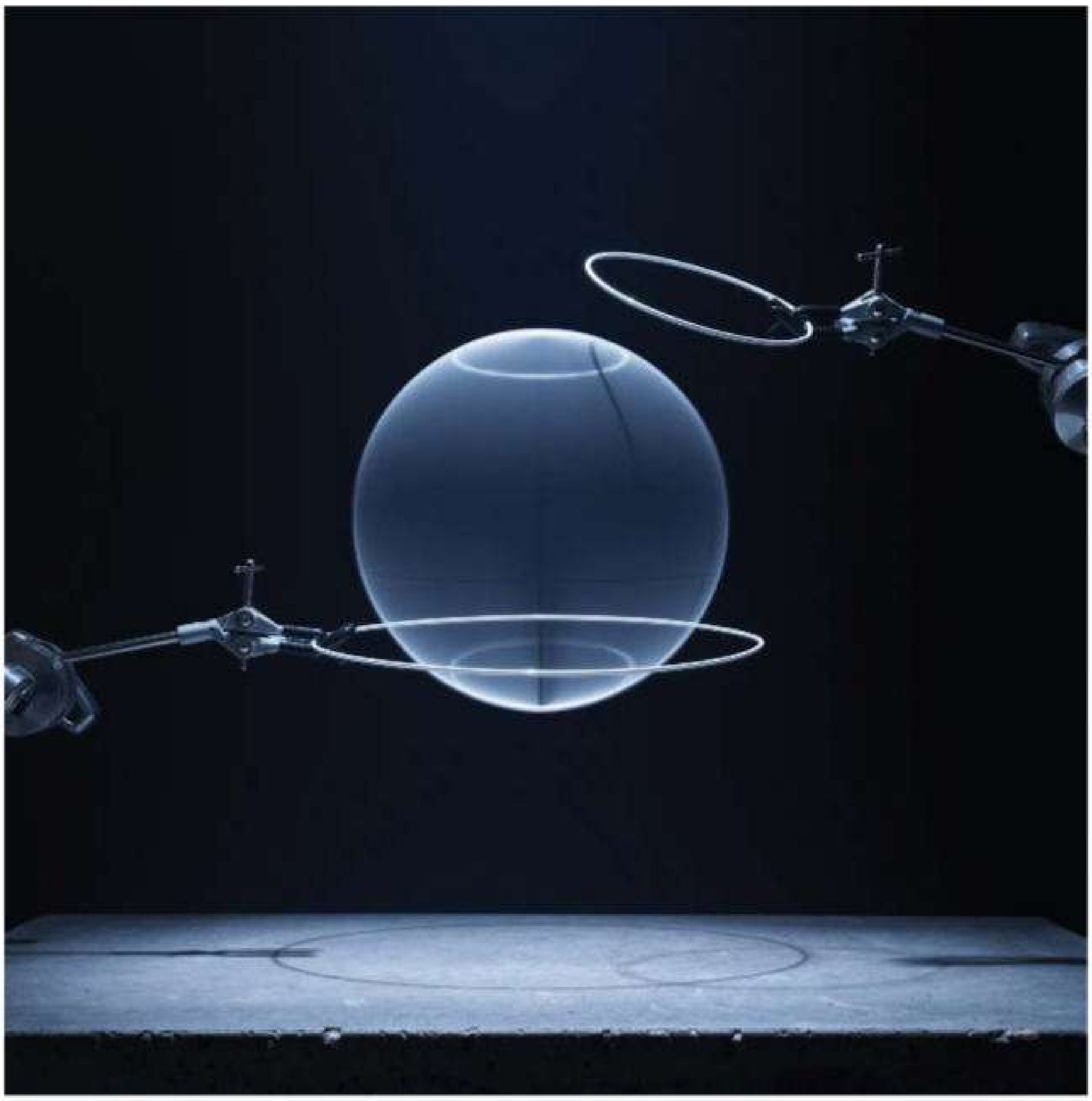
He was inspired by the work of Berenice Abbott, a US photographer known for her shots of New York architecture and urban design of the 1930s and for documenting physics through her black and white photos. She also shot images for school textbooks from the 1940s to the 1960s.

The shimmering image on the left shows a coil of wire in motion, representing electric current. The movement throughout the metal coil gives the impression of electricty's flow, says White.

(continued overleaf)







The images in the top row of this spread represent (left to right) the base quantities of length, luminous intensity and mass.

Length is shown as laser light bouncing off a mirror, while luminous intensity is depicted as a blackboard tilted increasingly further away from the camera, with light intensity increasing as more light is revealed to the lens. White used multiple exposures to create this image.

For mass, he span a wire hoop and used a long exposure time so that it looked like a sphere. This, he says, underlines how mass also determines an object's gravitational attraction and isn't always what it seems. He adds that the sphere's presence was amplified by the acceleration of the hoop's revolutions, and "incorporating other hoops nearby gave a nod to the fact the sphere was, in fact, the same object", as well as alluding to the mass gravitational pull of other objects.

The images below (left to right) represent amount of substance, temperature and time. To depict amount of substance, White made a single glass cube look like nine cubes by moving the camera lens over multiple exposures.

For temperature, he set up a swinging tube with a light source on each side and used a long exposure time to capture its blurred motion, representing the increased movement of particles as they heat up. He flashed one light on and off continuously to freeze the motion of the swinging tube on one side, while the other light remained on to create the blurred effect.

Finally, time is captured by two burning candles, spaced apart to give a different sense of perceived time. White added glass in front of them "to obscure the view and create multiple abstractions of the candles".

Base Quantities is available on White's website: gregwhite.tv.

Gege Li

Into the silence

Riz Ahmed turns in an impressive performance in *Sound of Metal*, a film about a heavy metal drummer who loses his hearing, says **Francesca Steele**

Film

Sound of Metal
Darius Marder
Amazon Prime UK, 12 April

COURTESY OF AMAZON STUDIOS

Riz Ahmed plays Ruben, a drummer who loses his hearing

LISTEN. What can you hear? If you have fully functioning hearing, the whirring of your coffee machine, perhaps, the background chatter of talking – pre-pandemic, the hubbub of a bar or the clamour of a gig. Now, imagine you can hear nothing. What would that be like? And what if hearing was your job?

This is the situation facing Ruben (played by Riz Ahmed), a burly former heroin addict with peroxide hair, who has replaced drugs with playing the drums in a heavy metal band and travelling from gig to gig with his girlfriend and bandmate Lou (Olivia Cooke).

Ruben has been clean for four years, but his post-addiction life isn't exactly calm. He has "please kill me" tattooed on his chest. He starts his days with turmeric smoothies and press-ups, but ends them performing music that sounds like rage distilled into rhythm. The compulsive mindset isn't gone, it has just been redirected.

Then one day, at a record store, Ruben starts to lose his hearing. Voices become muffled, and within days, he barely hears anything at all. A doctor tells him that cochlear implants, surgically implanted devices that electrically stimulate the auditory nerves, are possible, but cost up to $80,000 and aren't covered by insurance. Ruben cannot work. He cannot hear. The life he has built hangs on the edge.

Director and co-writer Darius Marder has experimented with an innovative and affecting soundscape that allows us to hear the way Ruben hears. The low-level buzz of everyday living is replaced with a frightening quiet.

Worried that Ruben will return to drugs, Lou finds him a community centre for deaf people with addictions run by Joe (Paul Raci), a Vietnam veteran who lost his hearing after a bomb exploded, and who strongly believes deafness shouldn't be considered a disability.

> **"Sullen refusal to accept a changed reality slowly morphs into acquiescence and then a fragile enjoyment"**

At first, Ruben finds dinner with the others at the centre disturbingly silent and strange. But his mannerisms become less febrile, and we see a burgeoning affinity with his peers emerge through low-key sports games, and one particularly touching scene where he teaches deaf students how to play the drums.

Yet, even as Ruben semi-flourishes in the unexpected peace of a soundless world, the knowledge of what could be – cochlear implants and his old life – chips away at him.

When he can finally afford them after making sacrifices that may damage his personal life, the unexpectedly distorted din the implants offer – all underwater muffles and high-pitched screeches – repels him.

A question that goes unanswered in the film is why Ruben isn't properly prepared by his doctors for the limitations and drawbacks of the implants: the strangeness of the sounds that he (and we) can now hear. It is clear, however, that his old life is lost.

Music is Ruben's job, so it is easy to sympathise with his mission to recover his hearing, but this puts him up against those at the community centre who celebrate deafness. Joe is very clear that Ruben isn't welcome after his surgery. The reasons for this seem both unfair and reasonable. However hard, Ruben must make a choice.

Ahmed's performance, in which strength and fragility jostle for supremacy, entirely merits his Golden Globe and Oscars best-actor nominations. He portrays Ruben's vulnerability with every panicked glance, while his sullen refusal to accept a changed reality slowly morphs into acquiescence and then a fragile enjoyment.

Sound of Metal is a captivating watch that will have you thinking about how deafness is viewed, both by the people who experience it and society as a whole. A beautiful scene in which Ruben removes his implants to the sound of blissful silence shows us that sometimes contentment lies in the strangest places. ▮

Francesca Steele is a film critic and writer working in London

Waking up to tech troubles

From virtual assistants to facial-recognition systems, our tech is shot through with inequality. **Layal Liverpool** discovers how to fix it

Book

Your Computer is on Fire
Edited by Thomas Mullaney, Benjamin Peters, Mar Hicks and Kavita Philip
MIT Press

TECHNOLOGY is so embedded in our lives that we can sometimes forget it is there at all. *Your Computer is on Fire* is a vital reminder not only of its presence, but that we urgently need to extinguish the problems associated with it.

The book challenges us to a radical rethink so that we can tackle a large range of problems, from algorithmic bias to climate change. These are addresed in a collection of essays, each highlighting problems in our relationship with technology and proposing ways to fix them.

To solve the issues of race and gender bias in algorithms, for instance, Mar Hicks at the Illinois Institute of Technology, Chicago, says we must recognise that these are deeply embedded features of the tech we rely on, not mere bugs. "These failures are not simply accidents," Hicks writes, "they are features of how the systems were designed to work and, without significant outside intervention, how they will continue to function."

The consequences of algorithmic bias can be severe, as in the case of facial-recognition software erroneously flagging up innocent people as criminals or as suspects in crimes they haven't committed, says Safiya Umoja Noble at the University of California, Los Angeles. But it isn't too late, she writes: "We have a significant opportunity to transform the consciousness embedded in artificial intelligence and robotics, since it is in fact a product of our own collective creation."

***Your Computer is on Fire* gives many examples of how our tech is often developed by and designed to work for a select few, despite having a diverse range of users globally. Halcyon Lawrence at Towson University in Maryland writes that for speakers with a "nonstandard accent" – including herself, as a speaker of Caribbean English – "virtual assistants like Siri and Alexa are unresponsive and frustrating".**

Even something as basic as the QWERTY keyboard was designed around the English language, with complicated adaptations bolted on over time to accommodate speakers of languages such as Arabic and Chinese, writes Thomas Mullaney at Stanford University, California.

In addition to supporting programmes to introduce more young people from diverse backgrounds to coding, big tech needs to do more to increase diversity in its own institutions, particularly at the top, argues Janet Abbate at Virginia Polytechnic Institute and State University in Blacksburg.

The collection also interprets its central metaphor in a more literal sense, with Nathan Ensmenger at Indiana University in Bloomington arguing that we need to reckon with the physical impact our current use of technology is having on the planet. His chapter, "The Cloud is a Factory", starts by recognising that cloud computing is "profoundly physical", requiring enormous amounts of energy, resources and labour.

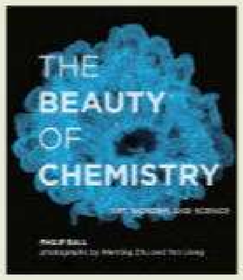
This theme is picked up by Benjamin Peters at the University of Tulsa, Oklahoma, when he writes: "The globe is ablaze, and few have the collective language to call to put it out. This book sounds out a call for that language... The challenge of anyone who lives in our broken world is not to delay to some future date the fact that the needs of the many outweigh the privileges of the few here and now."

***Your Computer is on Fire* asks more questions than it answers, but they will all be vital in challenging the world to make our technology better and fairer.** ▮

LAPS/GETTY IMAGES

Most keyboards reflect the cultural domination of the English language

Don't miss



Read

The Beauty of Chemistry captivates Philip Ball, as he explores unusual photos drawn from the online exhibition Envisioning Chemistry. Methods used to capture the images include high-speed, time-lapse and infrared photography.

Explore

Symbiosis is a virtual reality trip to a post-human world teeming with tech hybrids. Dutch design collective Polymorf took inspiration from the ideas of biologist and postmodern feminist Donna Haraway. Catch it on the group's website from 10 to 18 April.

Watch

Them, Amazon Prime Video's new anthology series created by Little Marvin and Lena Waithe, explores terror in the US. It begins with "Covenant", set in 1953, about a black couple threatened by forces both real and supernatural.

MIT PRESS; POLYMORF; PRIME VIDEO

The games column

The paradox of time

Time travel as a key feature of a game is great fun, from rewinding time in *Prince of Persia* to fighting alongside past selves in *Super Time Force*. And classic RPG *Chrono Trigger* is always worth revisiting, says **Jacob Aron**

Jacob Aron is *New Scientist*'s deputy news editor. Follow him on Twitter @jjaron

UBISOFT

In *Prince of Persia*, a magical dagger lets you rewind time

NEARLY all video games involve a form of time travel: if you die in a game, or even simply mess up, most will let you reload and have another go. But some games make a real feature of it, and this month I'm looking at my favourites.

Prince of Persia: The Sands of Time and its sequels literally turn reloading your game into a feature. The titular prince has a magical dagger that allows you to rewind time for a few seconds, perfect for jumping sections that involve dodging traps with split-second timing. The dagger can only be used a few times before it has to be recharged, so you need to choose carefully when to use it.

As time travel goes, simple rewinding is pretty mundane. The puzzle game *Braid* takes a more interesting approach. Each set of levels involves using some form of time manipulation to traverse a *Super Mario*-esque world. The first set follows the same rules as *Prince of Persia*, but subsequent levels introduce more complications, such as tying the passage of time to your movement in space, so that moving left rewinds time but moving right lets it flow forwards. You soon find yourself holding the past, present and future in your head at once.

One set of levels in *Braid* lets you record your actions, then rewind to replay the level in tandem with your recording – handy if, say, you need to be in two places at once to both activate a switch and go through a door.

> **"You jump between time periods, including a dinosaur-dominated deep past and a post-apocalyptic future"**

Other titles have spun this concept into entire games. The jauntily titled *The Misadventures of P. B. Winterbottom* lets you create multiple recordings and even move them about with a whack of an umbrella.

Taking this even further is *Super Time Force*, a cartoonish shooter game that sees you rewinding time to fight alongside past selves and even stop them being killed, creating paradoxes that translate into power-ups. Speaking at the Game Developer's Conference in 2014, Kenneth Yeung, one of *Super Time Force*'s developers, explained they were inspired by science to solve some of the challenges that arise when you create such a game, though that might be a stretch.

For example, Yeung said they looked to quantum physics for the idea that objects can only interact with the world if they have an observer, allowing the developers to avoid creating enemies who are shot off-screen by one of your past selves – nothing to do with the quantum mechanics I understand!

Of course, developers can just ignore paradoxes and the like and focus on using time travel to create a great story. The best game of this type is *Chrono Trigger*, a Japanese role-playing game from 1995 with an amazing soundtrack. Initially set in a fairly typical fantasy world, you play as a band of misfits trying to stop the end of the world and jump between periods, including a dinosaur-dominated deep past and a post-apocalyptic future.

Chrono Trigger indulges in all the classic time-travel tropes. Early in the game, the party travels back 400 years, where one character is mistaken for her similar-looking ancestor, ultimately leading to her never being born. Later, you pick up a robot companion in the future, travel back to the past and leave it to spend centuries growing a forest before reuniting in the present – an example of the "going the long way round" time travel much beloved by *Doctor Who*.

As befits a game about time travel, I have enjoyed revisiting *Chrono Trigger* many times over the years, even if nothing ever really changes. ▮

Games

Braid
Number None
PC, Xbox 360, PlayStation 3, Android

Chrono Trigger
Square
SNES, PlayStation, Nintendo DS, PC, Android, iOS

Prince of Persia: The Sands of Time
Ubisoft Montreal
PC, PlayStation 2, GameCube, Xbox

Super Time Force
Capybara Games
PC, Xbox One, PlayStation 4

The Misadventures of P. B. Winterbottom
The Odd Gentlemen
PC, Xbox 360

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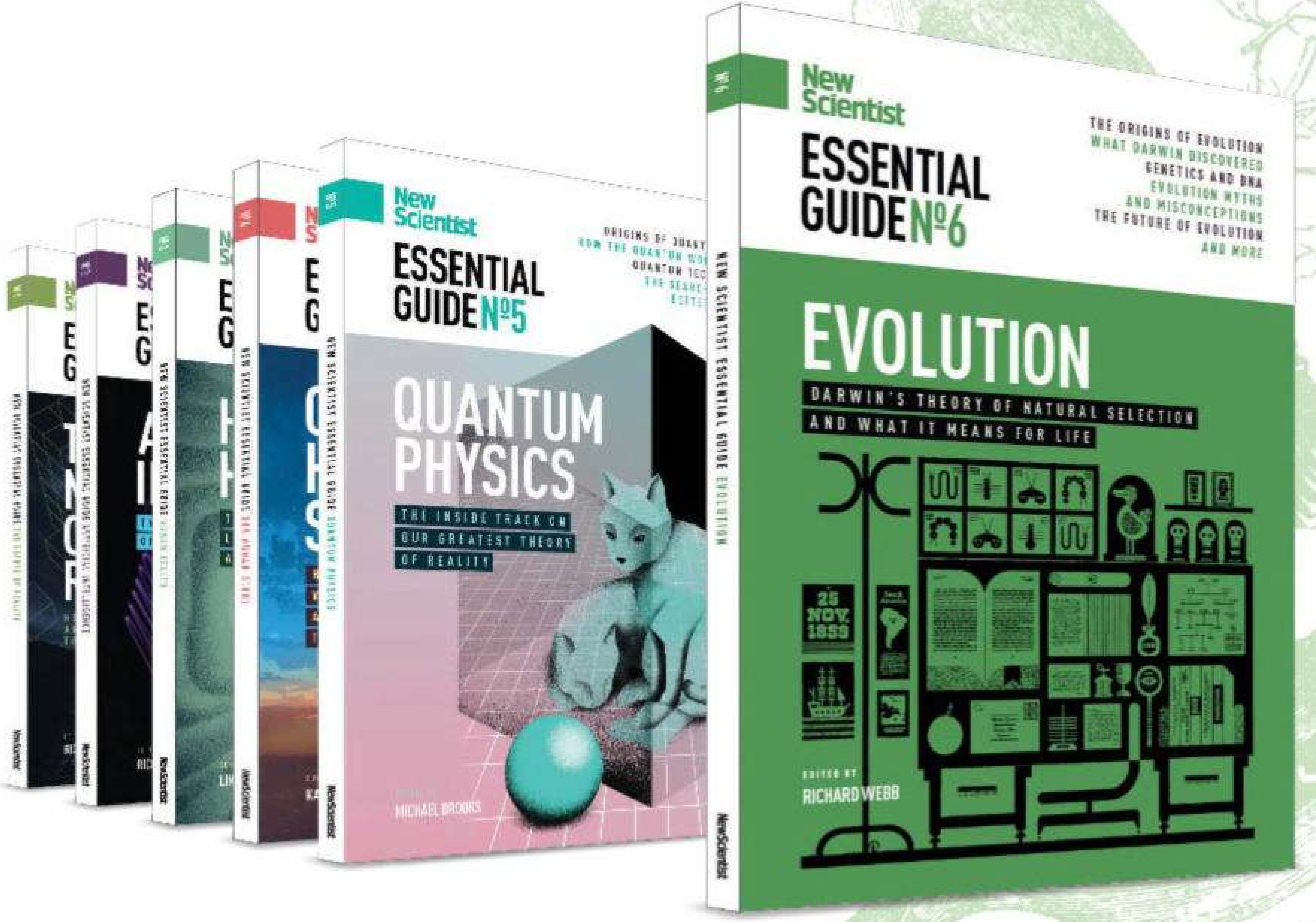

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Clever creatures

The brains of the smartest animals seem to work remarkably like our own, finds **David Robson**

BARELY a month goes by without a new tale of animals behaving brightly. There are orangutans that craft umbrellas out of plant leaves, and chimps that employ stones as hammers with a technique that is uncannily similar to one seemingly used by our Stone Age ancestors. In Bali, long-tailed macaques steal from tourists and then exchange their swag for edible rewards – and they have learned to target high-value items as if they appreciate the basic principles of economics. Hyenas employ the art of deception, with low-status individuals sounding an alarm call that scares their rivals away from a tasty carcass. In one UK zoo, several parrots curse copiously, apparently to entertain visitors. Pigs have been taught to play video games, rats can learn the rules of hide-and-seek, and let's not forget the golfing bees.

Superficially, these behaviours certainly seem smart. But what do they really reveal about animal intelligence? The human mind is remarkable for its innovation and problem-solving across many different domains. Do other animals have the same sort of brains, or are their headline-grabbing antics no more than party tricks that require little complex reasoning?

Scientists have begun devising elaborate tests to tackle this question. Like our own IQ tests, they allow researchers to assess the capacity of an animal's mind, compare the mental abilities of different individuals and identify factors that lead to superior performance. The findings have been a revelation. They provide some fascinating insights into the anatomy of intelligence. And they may even shed light on the evolutionary origins of our own minds.

Our current understanding of human intelligence was born in the early 20th century, when psychologist Charles Spearman noted that children's performances in school subjects as diverse as French, mathematics and music were often correlated with each other. Using sophisticated statistical techniques, Spearman was able to identify the shared element that apparently reflected someone's general intelligence, dubbing it "g". He saw it as a form of "mental energy" serving all kinds of problem-solving and learning, and noted that some people had it in greater abundance than others.

> **"Our general intelligence is thought to give us our unique flexibility of thinking"**

The subsequent development of IQ tests, with their measures of memory, vocabulary, processing speed and non-verbal reasoning, aimed to capture differences in that general intelligence. Over the years, these tests have come under some criticism. Nevertheless, long-running studies show that they can predict some important outcomes in life, like someone's academic success and their performance in various professions.

Because our general intelligence is considered to give us our unique flexibility of thinking, many scientists believed that it must have emerged relatively recently in evolutionary terms, in our ancestral lineage. Other animals, they suggested, had evolved more modular minds, with each skill existing independently from the others. That being

BRETT RYDER

the case, there would be no point in even attempting to measure an animal's g. "Non-human animals were thought to have evolved very specific solutions for very specific small problems," says Judith Burkart, an evolutionary anthropologist at the University of Zurich in Switzerland.

The idea of a modular mind fitted with the belief that animals behave mostly through instinct without much underlying "thought". It also made sense in terms of efficiency and reliability: evolving small, additional modules was considered to be less costly than general intelligence, which was assumed to need disproportionate amounts of brain tissue. "It is intuitive to think that you can evolve something by simply adding a little brick of Lego," says Burkart. In reality, however, this modular mind idea doesn't tally well with our knowledge of brain structure. And the growing recognition that the same neural areas often serve many different skills led some, including Burkart, to question the basic premise.

The first evidence of non-human general intelligence came from studies of mice and rats in the late 1990s and early 2000s. Like the human IQ tests, these experiments included a battery of tasks assessing different skills. One test measured how quickly the rodents learned to associate a sound with an electric shock. Another featured tasty snacks placed in three cups marked by different odours. In only one – the cup with a minty smell – was the food accessible to the rodent, and the researchers timed how long it took for each animal to learn this rule. In a third and fourth task, the animals had to navigate different kinds of mazes.

Rodent reasoning

If the rodent mind were built from many different modules, you wouldn't expect an individual to have a similar aptitude for the different tasks. Yet each one did: the researchers identified a common g factor that seemed to reflect a general, underlying cognitive ability. What's more, g appeared to account for around 40 per cent of the difference in individual performance across the tasks – very similar to the proportion seen in human intelligence tests. Even more striking was the distribution of the scores among the group, which followed the famous bell-shaped curve, with most clustering around the mean performance and much fewer at the high or low extremes. It is exactly the same distribution that is seen in human IQ.

> **"Rodent IQ follows a bell-shaped curve – the same distribution that is seen in human IQ"**

A raven's performance on IQ tests is similar to that of primates

SVEN ZACEK/NATUREPL

By the early 2010s, primatologists had started to take a keen interest in the findings, with some devising a battery of tests to explore chimpanzee intelligence. To show their spatial memory, chimps had to remember the location of food, after it had been hidden. For a test of causal reasoning, a peanut was concealed in one of two boxes. Then, based purely on the sound – whether it rattled – a chimp had to pick which container held the treat. Other tasks tested communication, by seeing whether a chimp would respond to a human pointing at a particular object, and tool use, by seeing whether a chimp could choose an appropriate object to retrieve food that was out of reach.

Testing 99 chimps in this way, neuroscientist William Hopkins at Georgia State University in Atlanta and two of his colleagues found evidence of a g factor that could explain the correlations in the performance of individuals across the tasks. Once again, the variation followed a bell-shaped curve. Many of the chimps were related and, by comparing the individual performances across their family trees, the researchers were able to explore how much of that intelligence was inherited. Overall, they found that around half of the variability was due to genes, which is amazingly consistent with the studies of human intelligence. "I was fairly stunned," says Hopkins.

Using similar experiments, scientists have now identified g in the cognitive abilities of a range of animals, including orangutans, cotton-top tamarins, bowerbirds and magpies. "The science is still in a very early stage," says Rosalind Arden at the London School of Economics, who in 2016 determined that border collies have g. As a result, she and others who have found g in animals are cautious about interpreting their findings. It will be important, says Arden, to show that the measured differences in intelligence actually

Thieving macaques seem to understand basic economics

NATURE PICTURE LIBRARY/ALAMY

correspond to meaningful outcomes – in the same way that IQ scores predict academic and professional achievement. For a border collie, for example, you might compare the measured differences with their performance in dog training classes. For an animal in the wild, it may be their overall survival.

Even with more research, Arden is sceptical of the idea that we will ever be able to quantify the differences in intelligence between species. "The problems facing a cat are different from the problems facing a capuchin or camel," she says. In other words, two species may show a g factor underlying their individual skill sets but have evolved different strengths or weaknesses based on what was most necessary for survival. For example, dogs and octopuses are both highly intelligent creatures but, depending on the particular tasks used to test them, each could look either very smart or very stupid. And, purely at a practical level, different species may not be physically capable of the same tests: a dolphin, for example, lacks hands, so it cannot manipulate objects in the way a primate would.

Corvid cognition

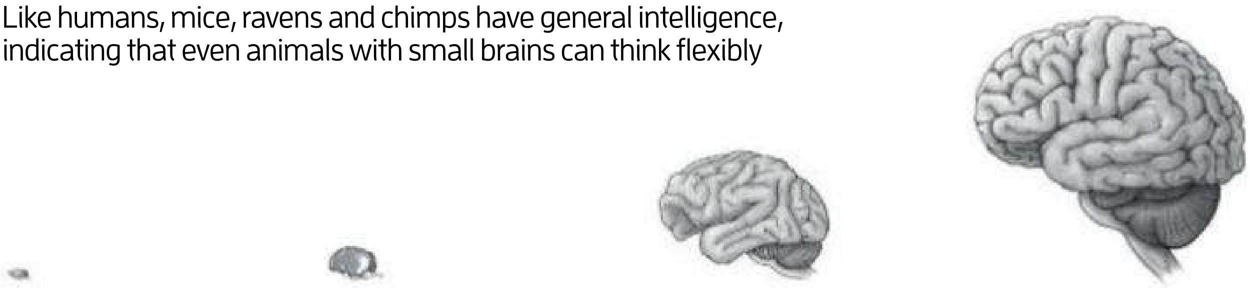
It may not be possible to rank the overall intelligence of different species, but other researchers believe that general comparisons could be enlightening. Simone Pika at the University of Osnabrück, Germany, is one of them. She and her colleagues recently tested ravens on a battery of cognitive tasks that was originally designed for primates. Members of the corvid family – crows, magpies, jays, ravens and the like – have long been known for their sophisticated behaviours, which include tool use and deception. They are even thought to exhibit metacognition, or the capacity to assess their own knowledge and exhibit self-doubt. Given these findings, it is tempting to wonder how their minds compare to those of apes, especially given that the anatomy of bird and mammal brains is so different.

Pika and her team put the ravens through a range of tests from causal reasoning and quantity appreciation – whether they would choose a plate with more pieces of food, for instance – to communicative and social skills, such as whether a raven could follow an experimenters' gaze to find hidden food. For most of the tasks, the ravens' abilities were remarkably similar to those of chimps and orangutans. The big difference was that they emerged at a much younger age – surprisingly young, even given that their lifespan is far shorter than that of primates. "The ravens' performance was already really striking at just 4 months," says Pika. At this stage, the young still depend on their parents, but they have started to find their own food, giving them many opportunities to put their reasoning and social skills to use, she says.

Comparing the brains of apes and ravens hints at some common qualities that appear to give rise to greater general intelligence. The advanced abilities of primates are thought to have come from the rapid growth of the neocortex, the folded outermost layers of the brain. Indeed, there is some evidence that primates with bigger neocortices are smarter. Bird brains are much smaller and lack these layers, which historically led some people to take a dim view of their abilities. ›

Brain size isn't everything

Like humans, mice, ravens and chimps have general intelligence, indicating that even animals with small brains can think flexibly



Mouse	**Raven**	**Chimp**	**Human**
0.4g	10.2g	380g	1350g
71 million neurones	1.2 billion neurones	28 billion neurones	86 billion neurones

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“The conclusion was that, without this neocortex, there’s not enough brain material to make higher cognition possible,” says Pika. However, recent research suggests that corvids make up for this with efficient packing: the neurons in their forebrain are arranged so densely that the total number of cells equals or even exceeds that in primates with much bigger brains. The neural wiring, linking different regions, is also similar in both groups. “It seems that if you want to be smart, you really need to have a high number of neurons and they should all be very well connected,” says Pika.

KRISTINA BLOKHIN/ALAMY

The clever antics of rats aren’t merely party tricks

Why be smart?

As well as giving an insight into the anatomy of brainpower, g tests in non-human animals may also help us understand the evolutionary forces that lead to more flexible thinking. If greater general intelligence does require more brain growth and maintenance, as many researchers believe, then it must offer some big advantages to offset the costs. There are a few competing ideas. One is the cognitive buffer hypothesis: the idea that greater general intelligence allows an animal to cope with an unpredictable environment – improving, for instance, its capacity to forage for food in varied climates. Another, the Machiavellian intelligence hypothesis, considers competition between individuals as the driving force. For animals that live in big groups with complex hierarchies, it is important to keep track of allegiances and to outsmart rivals, all of which is thought to require greater brainpower.

Related to both of these ideas is the cultural intelligence hypothesis, which concerns the sharing of social information between individuals. A solitary animal may be able to find new ways of foraging, for example, but animals that live in a group can capitalise on the innovations of others without putting in that individual effort. “Using social information is much more efficient than trial and error,” says Burkart. The higher an animal’s general intelligence, the better it is likely to be at taking advantage of advances made by others. According to this hypothesis, greater general intelligence should therefore evolve in animals with plenty of opportunities for social learning. When Burkart and her colleagues examined the evidence for general intelligence in non-human animals, they concluded that the cultural intelligence idea is a promising explanation for general intelligence.

Some early evidence for this assertion comes from comparisons of Sumatran and Bornean orangutans. The two species are thought to have diverged around a million years ago. Although their habitats today are very similar, the Bornean apes are solitary and dispersed, whereas the Sumatran ones tend to live in denser populations, which should give more opportunities for social learning. Observations in the wild show that young Sumatran orangutans do take advantage of this: juveniles spend more time watching others than their Bornean counterparts do. The result is a broader repertoire of socially learned behaviours. They use leaves as a type of glove to handle spiny fruit, for example – a behaviour not typically seen among Bornean orangutans.

> **“This may help us understand the evolutionary forces that lead to more flexible thinking”**

According to the cultural intelligence hypothesis, the potential exchange of social information should have driven the evolution of a quicker and more flexible brain that is more adept at all kinds of problem-solving. Sure enough, Burkart’s colleagues at the University of Zurich have found that Sumatran orangutans performed better on a range of cognitive tasks, such as extracting food from a puzzling contraption, which would require higher general intelligence. Their brains are also slightly bigger than those of the Bornean orangutan, supporting the notion that higher general intelligence requires greater reserves of neural tissue.

Human evolution would, of course, exemplify the cultural intelligence hypothesis of brain evolution. From the first stone tools to today’s books, computers and smartphones, our lives have depended on our ability to exploit the advances of others. However, when we fully explore the extent of animal intelligence, we may find that many other creatures are on a similar path. ■

David Robson is the author of *The Intelligence Trap: Revolutionise your thinking and make wiser decisions.* Follow him on Twitter @d_a_robson

How climate change hits nature

A warming world is piling pressure on already struggling biodiversity. We need to tackle both problems together, finds **Michael Le Page**

A kangaroo and her joey survey the aftermath of a wildfire in Mallacoota, Australia, in 2020

JO-ANNE MCARTHUR / WE ANIMALS/NATUREPL

THE Great Barrier Reef is already in a critical state. Rising sea temperatures are killing corals faster than they can recover. As temperatures continue to increase, more and more of the reef will die, along with the rich variety of life and the AUS$6 billion tourism industry that depend on it.

It is one headline-grabbing example among many. The continued rapid warming of the planet would wipe out many species, even if it were the only change happening. As it is, a sixth mass extinction in Earth's history is already under way as farms replace forests and factory ships overfish the oceans.

The heating of the planet will push many struggling species over the brink. Some will just have no place left to go. For biodiversity, climate change is, in military jargon, a threat multiplier. Worse still, measures to limit warming often don't take biodiversity into account. Some, such as the push for biofuels, directly harm it.

Yet there is little that is inevitable about what happens next. We might not be able to save all the species under threat, but we can save an awful lot of them. "We could cut the number of extinctions in half," says John Wiens at the University of Arizona. "I think that's the biggest cause for optimism."

But our chances are better if we think more smartly about the links between biodiversity loss and climate change, and tackle both of these issues together. Done right, a rescue plan for nature can be part of a plan for saving humanity from the worst of climate change – and vice versa.

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About this feature

This is the fifth and final feature in our "Rescue Plan for Nature" series produced in association with the United Nations Environment Programme and UNEP partner agency GRID-Arendal. *New Scientist* retains full editorial control over, and responsibility for, the content

MARK BOWLER/NATUREPL

“Many species are already moving to stay within their comfort zone”

The world has warmed around 1°C since pre-industrial times. That is already having a dramatic effect on wildlife. In the Arctic, for example, the loss of more and more sea ice each summer is affecting many animals, from walruses to polar bears.

Unique species

Polar inhabitants have nowhere colder to go, but many creatures elsewhere are already moving to stay in their comfort zone. Some marine species, including mammals, birds, fish and plankton, have shifted their ranges by hundreds of kilometres. Other effects are more subtle. Oceanic low-oxygen zones are expanding because oxygen is less soluble in warm water. This is forcing species such as blue sharks to stay closer to the surface, making them more likely to be caught by fishing boats.

Rising sea levels, meanwhile, could wipe out species as low-lying islands are inundated. Mainland species are also at risk, such as the few hundred Bengal tigers in the Sundarbans, a network of mangrove forests along the coast of Bangladesh and north-east India. The effects of habitat destruction and rising water levels mean there will probably be no suitable habitat left there for these tigers by 2070.

Not all of those threats are as gradual as the melting of ice caps and the rising of sea levels. Extreme weather, fuelled by climate change, is one example. Hurricane Dorian, one of the strongest Atlantic storms ever recorded, may have wiped out several bird species in the Bahamas, including the Bahama nuthatch and the Abaco parrot, when it hit the islands in 2019. Warming-fuelled wildfires could also take out species with smaller populations. In 2015, for instance, fires in Western Australia burned much of the remaining habitat of Gilbert’s potoroo, one of the world’s rarest mammals.

A warming world isn’t bad news for all species. Some, especially small, highly adaptable and fast-reproducing ones, are thriving. But these tend to be things we regard as weeds, pests or unwanted invaders, such as mosquitoes, bark beetles and jellyfish.

So far, few species have been conclusively driven to extinction by climate change. The most clear-cut case is the loss of the Bramble Cay melomys (*Melomys rubicola*). This rat-like rodent was found only on its namesake island home, a tiny, low-lying Australian cay on the northern edge of the Great Barrier Reef. It died out some time after 2009 as rising sea levels led to the island being inundated during storms. Warming may have contributed to other extinctions as well. For example, climate change is thought to have aided the spread of a fungal disease called chytridiomycosis that has wiped out nearly 100 amphibian species.

So far, Earth hasn’t warmed much beyond the bounds of natural variations experienced over the past few million years. But many slower feedbacks, such as the melting of permafrost and the Antarctic ice sheet, have barely begun to kick in, so this will change.

We are heading into this with wildlife already devastated by our activities. Humans have altered three-quarters of all land and two-thirds of the oceans, according to a major 2019 report on biodiversity. More than a third of land and three-quarters of freshwater resources are devoted to crops or livestock.

It is in our own interests to turn things around. The “ecosystem services” that nature provides for free are worth trillions of dollars and underpin many livelihoods. For instance, hundreds of millions of people depend on coral reefs for tourism and the fish stocks they support, says Ove Hoegh-Guldberg at

OLE JORGEN LIODDEN/NATUREPL

Once the ice has melted, polar inhabitants have nowhere colder to go

GARY BELL/OCEANWIDE/NATUREPL

Bleached corals off Heron Island in Australia's Great Barrier Reef

the University of Queensland in Australia. "This is an issue of people as much as it is about ecosystems and biodiversity," he says.

By intruding into wild areas and exploiting wildlife, we are also giving pathogens such as the virus causing the covid-19 pandemic more chances to make the jump into humans or domesticated animals. Warming is generally expected to make matters worse, for example by allowing disease-carrying tropical mosquitoes to spread more widely.

Overall, though, the populations of most plants and animals have been greatly reduced, and they are already in shrinking, often fragmented areas. One recent study looked at the effect of future climate change on 80,000 species in 35 of the most wildlife-rich areas, including the Amazon rainforest and the Galapagos Islands. With warming of 5°C by around the 2080s, half of these species would no longer be able to survive in these areas.

In many parts of the world, even if suitable habitat remains, many species may not be able to reach it, because their paths are blocked by cities, roads, farms and fences. The same study found that if animals were able to move freely, 2°C of warming would result in the loss of 20 per cent rather than 25 per cent of species.

One issue with studies of this kind is that they assume species can't survive outside their current climatic range. But many are already evolving and adapting as their habitats warm. In Finland, for instance, tawny owls are turning brown as snow cover declines.

There is a limit to what evolution can achieve, though, especially in species that reproduce slowly. Not only is the climate starting to change much faster than it has during the past few million years, but many species have suffered huge losses of genetic diversity as their numbers have declined. This makes it much harder to adapt to a changing environment.

To get a better picture of how wildlife will cope, in a recent study Wiens focused on about 500 plants and animals worldwide, looking at where they have already become locally extinct as the world has warmed. His results suggest that what matters most is the maximum annual temperature, not mean temperature, as many other studies assume. "The most straightforward explanation is that it just literally gets too hot and they die," he says.

Extinction debt

Despite this, his conclusions are similar to those of many other studies, suggesting that about a third of terrestrial species could be lost altogether by 2070. "That could be cut in half by following the Paris Agreement and keeping temperature below an increase of about 1.5°C," says Wiens.

As dire as these forecasts are, they may underestimate future extinction risk. "There could be a lot more extinctions caused by things like sea level rise," says Wiens. "There's a whole bunch of other threats." It can take hundreds or even thousands of years for the full effects of changes such as habitat loss to play out – a phenomenon called extinction debt. In Europe, for instance, the number of extinctions happening today is more strongly linked to what happened a century ago than to current events.

One reason is that populations can

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PAUL WILLIAMS/NATUREPL

become unsustainable once they shrink beyond a certain point. And a decline in one species can have knock-on effects on many others, leading to cascading ecological effects. One New Zealand flowering shrub, *Rhabdothamnus solandri*, for example, is slowly declining in numbers after the loss of the birds that pollinated it.

Multiplying effects

Some threats to biodiversity can't be forecast with any certainty. For instance, people forced from their homes by disasters or conflict can have a severe impact on biodiversity in the places they flee to, rapidly deforesting vast areas and greatly reducing wildlife populations. Floods and storms displaced 15 million people in 2018 alone, and these numbers will rise as extreme weather keeps on getting more extreme. For some, there will be no going home: sea level rise will force hundreds of millions of people to move out of low-lying areas over the coming decades.

The combined effect of all these threats can multiply and be worse than any one alone. "For example, corals recover from bleaching episodes more slowly when they suffer stress from pollution, or damage from coastal development or poorly regulated sport or commercial activities," says Sandra Díaz at the National University of Córdoba in Argentina. Similarly, in tropical forests, unusually hot and dry years, combined with the creation of roads, greatly increase the chances of destructive fires, she says.

On the one hand, these multiplier effects mean we may be greatly underestimating our impact on biodiversity over the coming century. "Our best calculations and projections do not incorporate all the possible cascading and non-linear effects," says Díaz. "They are on the conservative side."

On the other hand, this shows the importance of protecting and restoring wildlife areas – and that the benefits of such actions could be even greater than we think. For instance, creating wildlife corridors or deliberately relocating species to more suitable areas may save those that would otherwise be doomed.

For all these reasons, there is growing awareness that climate change and biodiversity are inextricably linked, and that we need joined-up policies to tackle both. One consequence is that the separate UN conventions on biodiversity and climate change should be merged, says Eric Dinerstein of the environmental organisation RESOLVE in Washington DC.

"The two are so interdependent and the solutions are interdependent," he says. "We can't save biodiversity without staying below 1.5 degrees, and we can't stay below 1.5 degrees without saving biodiversity."

In general, more has been done to try to tackle climate change than to stem biodiversity loss. Unfortunately, climate policies often

REUTERS/LOREN ELLIOTT

A badly damaged house on Great Abaco in the Bahamas in the wake of Hurricane Dorian in 2019

New Scientist events

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"Climate policies often show anything but joined-up thinking"

ASHLEY COOPER/NATUREPL

Switching farmland to growing energy crops such as oilseed rape increases pressure on land elsewhere

show anything but joined-up thinking. Exhibit A are the various incentives or laws promoting biofuels because they are seen as "green". "There is no doubt that the push for biofuels has seriously harmed biodiversity," says Tim Searchinger at Princeton University.

Growing use of biodiesel is responsible for 90 per cent of the increased demand for vegetable oil since 2015, says Searchinger. In Europe, more than half of imported palm oil ends up powering cars, driving the destruction of wildlife and carbon-rich forests in South-East Asia for palm oil plantations. Europe is also fuelling deforestation elsewhere by importing wood to burn for energy, while still counting this as a means to reduce carbon emissions.

The fundamental issue that is overlooked is that land is limited. If existing farmland is switched to new uses such as growing bioenergy crops, more farmland is generally carved out of wild habitats elsewhere, destroying biodiversity and adding carbon to the air in the process. The situation is complex: a few biofuels, mainly those made from genuine waste, can be beneficial overall. But many policies wrongly treat any biofuel as green. With the aviation industry now eyeing biofuels as a way to claim it is limiting emissions, matters could get even worse.

If climate policies fail to take biodiversity into account, the reverse is often true, too. For instance, efforts to save the Iberian lynx are focused on the southern part of the Iberian peninsula, where conditions will become too dry for the cats this century.

Some measures really can help us preserve biodiversity and cut carbon emissions at the same time. In general, areas that are rich in wildlife also store lots of carbon, says Dinerstein. His team has mapped out what additional areas around the world, for example in the Amazon basin or on Madagascar and Borneo, need to be protected to help the greatest number of species and maximise carbon storage. Many other groups support this approach.

This could be done without taking existing farmland out of production and at a relatively low cost, says Dinerstein. In some places, tree planting with native species may be necessary, but often there is no need. "The most effective thing we can do is to allow degraded areas to grow back," he says – rewilding and restoring ecosystems, in other words.

Preserving biodiversity isn't just a fringe benefit of protecting carbon-storing trees, but is important to maximise carbon storage. In tropical forests, the largest trees typically have big seeds that are dispersed by animals, says Dinerstein – and they are the ones that are most valuable to loggers. "If we hunt them out, those massive, large-seeded trees are replaced with those with smaller seeds that don't grow as tall, don't grow as large and sequester much less carbon."

Better future

At the same time, we need to slow and eventually halt the clearing of land for farms. Encouraging people to eat less meat would help enormously. If everyone shifted to a plant-based diet, we would only need a quarter of the farmland used now, while vastly reducing the greenhouse gas emissions associated with producing food.

But with meat consumption increasing rather than falling, it is vital to maximise yields on existing farmland. "The expansion of farmland and the associated habitat loss is still very ongoing," says Emma Kovak at the Breakthrough Institute in California. "The intensification of farming can spare habitat for wildlife."

A low-intensity organic farm might have more wildlife on it, but it produces less food, which means more farmland is needed elsewhere in the world, she says. Per unit of food, high-intensity farming has a much lower impact. Kovak has shown that if the European Union had embraced higher-yielding, genetically engineered crops, it would have led to a substantial reduction in greenhouse gas emissions via less land use.

Despite the dire outlook, many researchers remain optimistic. "I'm incredibly hopeful," says Dinerstein. For a start, protecting more land would actually cost relatively little, he says. There is even hope for the coral reefs. "If we stabilise the climate, there is a very good chance that coral reefs will grow back over time," says Hoegh-Guldberg.

Many initiatives and studies around the world show that we can protect biodiversity and tackle climate change while offering a better and fairer future for people, says Díaz.

"But these studies also show, very clearly, that this will only work with very fast, very deep, very bold changes in the way we consume, eat, trade and value," she says. "The opportunity to shift gears and do what needs to be done for a better future will close soon." ■

Michael Le Page is a biology and environment reporter for *New Scientist*

The Mars biologist

Tanja Bosak chooses which rocks NASA's Perseverance rover will prep for a return trip to Earth, where they will be scoured for traces of ancient life. The most surprising outcome would be not finding any, she tells Jonathan O'Callaghan

ROCIO MONTOYA

PERSEVERANCE is the fifth rover that humans have landed on Mars. Its mission is the most exciting yet. While previous rovers have focused on exploring the planet's geology and potential habitability, NASA's latest robotic explorer is actively looking for signs of ancient life. It was an epic moment when Perseverance was lowered to the surface from a hovering sky crane in February.

No wonder the scientists behind it were jubilant. One of those celebrating was geobiologist Tanja Bosak at the Massachusetts Institute of Technology. She has long studied the evidence of Earth's earliest life in our geological record. Now she is bringing that expertise to bear on Mars.

This time, Perseverance is doing the field work for her. The rover is beginning to explore Jezero crater, which was once a Martian lake fed by rivers (see pictures overleaf). It is a fantastic place to hunt for traces of life, with just the right kinds of rocks for preserving fossils, says Bosak.

One of the most interesting aspects of Perseverance's work is choosing a selection of rocks that might contain traces of ancient life and preparing them for a return journey to Earth. The rover carries 43 pristine sample tubes, each of which will be filled and cached under its belly, then left for a subsequent mission to collect and launch back into orbit around Mars. The plan is for these to be picked up and returned to Earth as early as 2031. It is Bosak and her colleagues who have the responsibility of deciding which rocks make the cut.

Funnily enough, she thinks that not finding any traces of life would be the most fascinating outcome. After all, when they were young, the conditions on Mars and Earth were similar. For Bosak, if life never found a foothold on the Red Planet, it would be deeply mysterious.

Jonathan O'Callaghan: How does your work on Earth relate to Mars?

Tanja Bosak: Earth is the only planet where we know life evolved. But the early beginnings of this evolution are pretty murky because there is no good record. Our planet is very geologically active: it has a water cycle so rocks get eroded, buried, covered by other rocks and exposed to high temperatures and pressures. Thanks to that, it's hard to tell what life was like 3 billion years ago or even earlier.

One thing we do have from this period, and which I've studied, are fossilised structures called stromatolites. They are these layered assemblages of many tiny cells and they're the earliest evidence of life on Earth we have.

Getting the chance to ask whether there was also life at this early point on our closest planetary neighbour is something that every biologist longs for. The way we do it is to carry out experimental geobiology on Earth to work out how the signatures of life can be preserved. Then we go and look on Mars for rocks where that kind of preservation could potentially have happened.

What was it like to witness the moment Perseverance landed in February?

Incredible. This is the first space mission that I'm involved in. Just knowing some of the people involved, watching them be nervous and seeing how well everything seemed to go – I was tearing up.

We watched on NASA TV like most people, but we had a meeting organised on the virtual meeting place Gather.town just with team members to chat and rejoice together.

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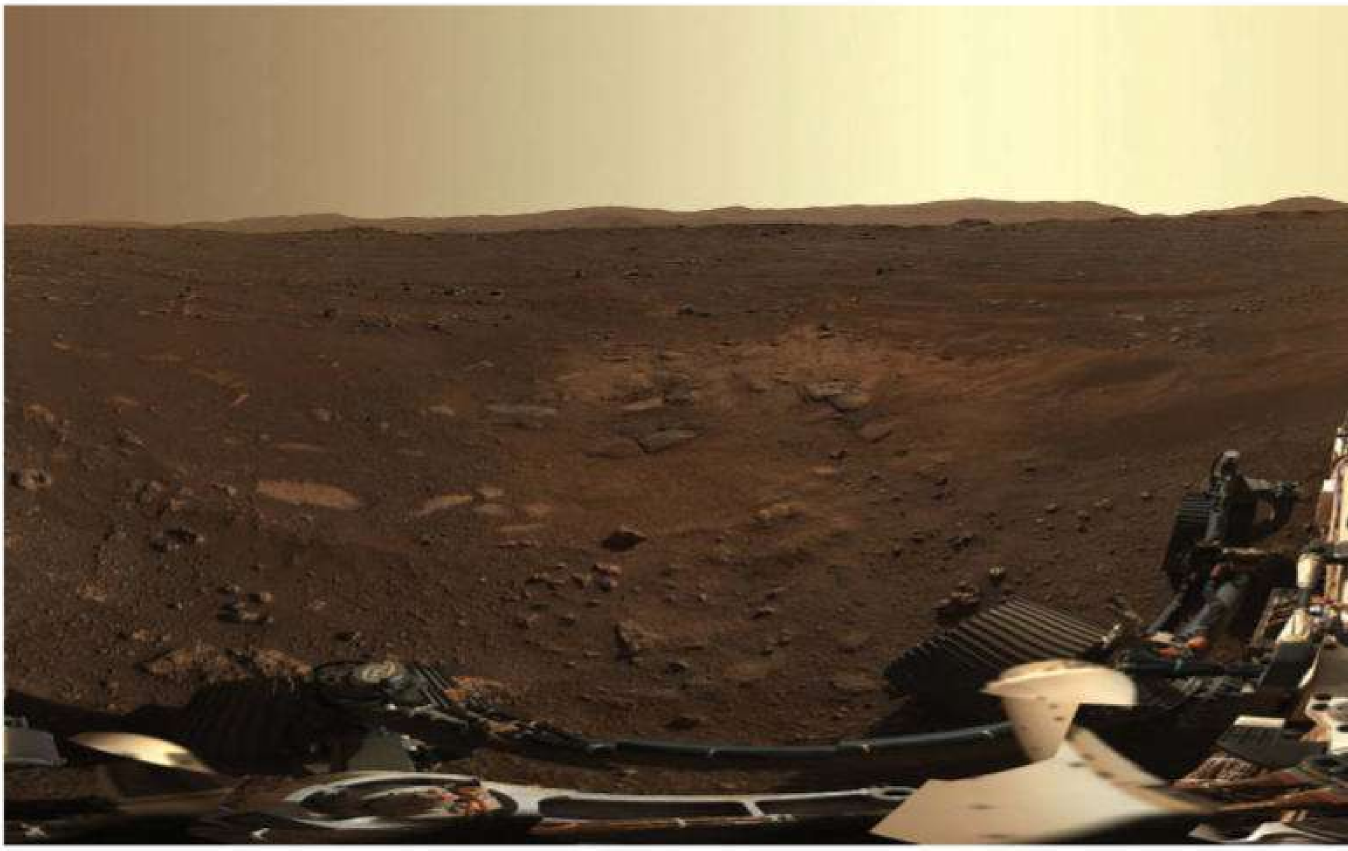

NASA/JPL-CALTECH/MSSS/ASU

There does seem to be a lot of excitement about this particular rover. Why do you think that is?
This is the first opportunity for us to get samples from a really well-understood geologic context on Mars. We picked a site that once had water, and now we have a hope of getting samples that we can investigate in all sorts of ways once they are brought back to Earth.

What is Jezero crater like and why was it selected as the landing site?
It is a fairly old crater that is heavily pockmarked and was filled with water at one point in Martian history. We know this because there's a surface feature that looks like a terrestrial river delta. Mars orbiters have shown us that there are various minerals present in the crater that could indicate conditions that were favourable for life.

It's these minerals that got people excited about Jezero. There are minerals called carbonates present that are similar to limestone. The stuff on Mars is magnesium carbonate instead of calcium carbonate. If these minerals were once colonised by microbes, they would have assumed certain telltale shapes that we can look for. There are also fine-grained sediments called mudstones that contain a lot of clay minerals. Microbial fossils or traces of organic matter could be buried and preserved in these sorts of sediments over billions of years.

Your job is to select some of these rocks that will be returned to Earth. Tell us about that.
There is a team of 15 of us. Everyone has expertise in different types of samples. Some people date rocks for a living, others look at the records of ancient magnetic fields, some people have experience with meteorites. We need all that expertise to select a set of samples that can address a lot of questions.

The rover has all sorts of instruments we can use to analyse the composition of the rocks. For example, we can measure the elements that are present, which tells us more about what kinds of rocks we're dealing with. Different rocks serve different purposes – you won't look for life in basalt, because it's an igneous rock and the heat and pressure it has experienced would have eradicated any traces of life. On the other hand, basalts may be an important tool to date the surface.

If we can recognise those telltale shapes related to life left in the carbonate rocks that I mentioned, then those would be great samples to acquire.

These rocks are certainly going to be iconic.
They will be just like the rocks that the Apollo astronauts brought back from the moon. They will be available to the scientific community in the decades to come, so it's important we record our methods carefully. Everyone will need to be able to understand what information went into the selection.

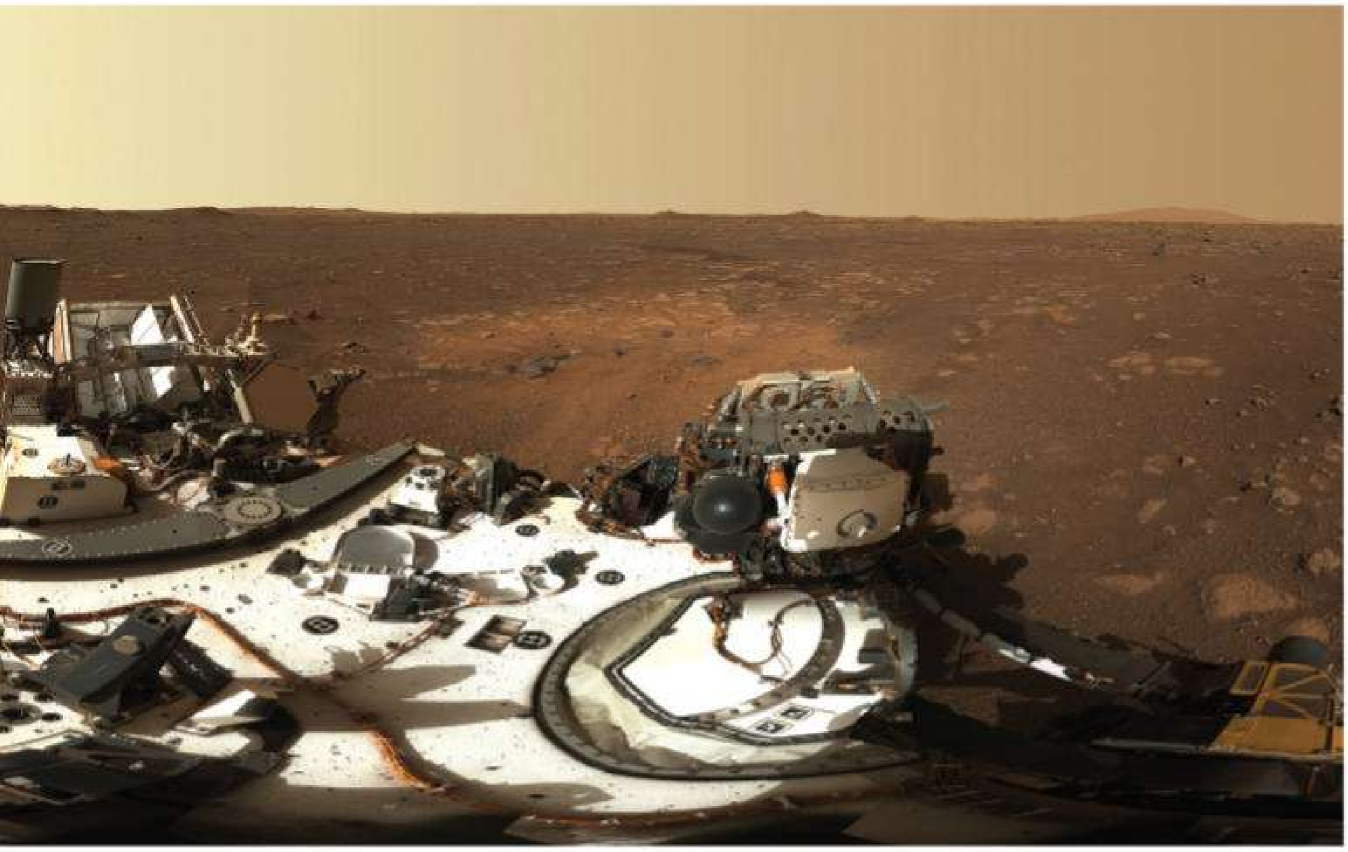
If we do find evidence of past life, what would it look like?
Nothing too obvious like a dried-up bone or a bird feather. It would be microscopic. Given that this terrain is so old, we can't hope for anything non-microbial. And if there was life on Mars, it could not have been huge. We don't have microscopes on the rover, so what we do is look for the best types of rocks and environments that could preserve something interesting. Liquid water is necessary for life – that's condition number one – so this is partly why Jezero was selected as the landing site. Then we have to go to the types of minerals that are the best at preserving potential evidence.

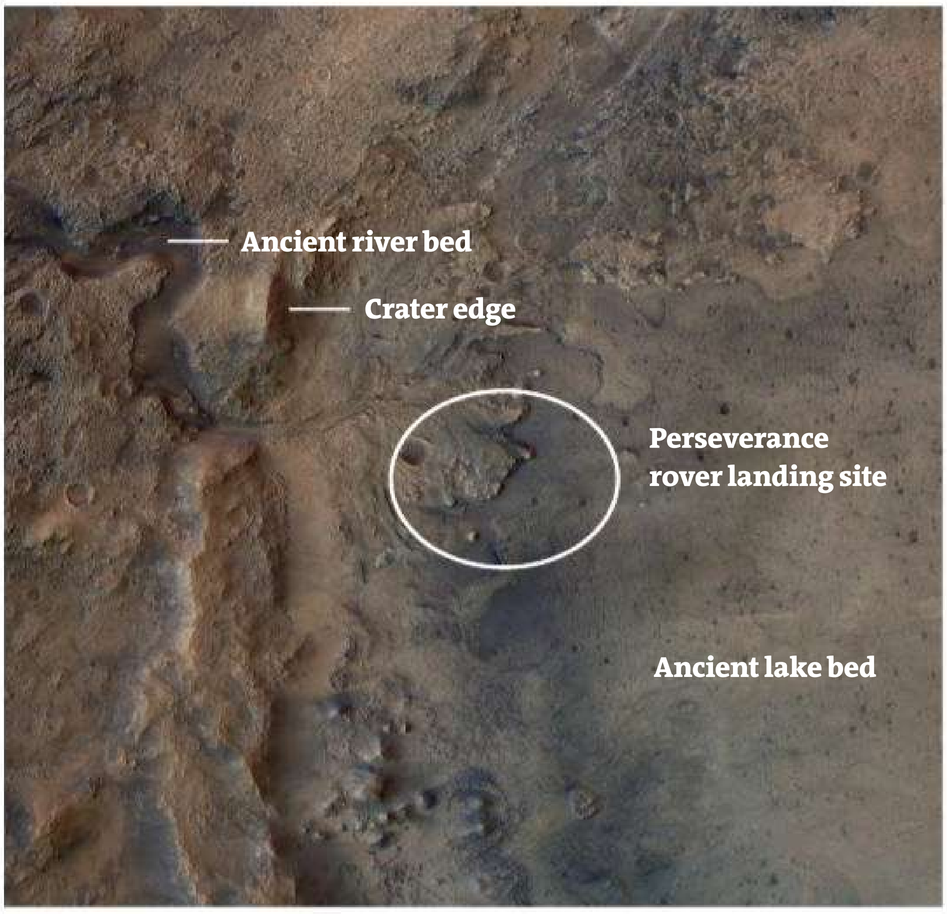
> "Evidence of life on Mars won't be something obvious like a dried-up bone or bird feather"

Might we find a Martian stromatolite?
I would love to see a stromatolite, but I don't think that is necessarily what we'll find. We do know that rocks on Mars could preserve structures equivalent to a stromatolite in principle. But we don't know enough yet about how geology works on the planet to know if that would happen in practice. This is part of the reason for wanting to bring these samples back to Earth. We will need to throw many different tools and analyses at these rocks. Finding life, if there is anything, may be at least a decade into the future.

What would gold-standard evidence for life look like?
The best-case scenario is that we find a sample of a mudstone, analyse it on Earth and find specific types of organic molecules. Or maybe we hit a patch of clay where a fossil is preserved that looks like an organism we would find on Earth. That would tell us that when there was water on Mars, there was life that looked very similar to life on Earth.

Finding something like this could tell us





ESA/DLR/FU-BERLIN

Above: Perseverance is sending back incredible images of Jezero crater

Left: Photography from orbit shows the edges of Jezero crater and an ancient river delta

a lot about the parallel evolution of life. Mars is so close to us, so this would address how different life could be on a nearby planet.

Are you expecting to get a conclusive answer on whether life existed on Mars as a result of Perseverance?

No. Anyone who has looked at fossils on Earth knows that the preservation of fossils or biosignatures is patchy. If we had infinite time and rovers on Mars, we could do a more comprehensive study.

But it's also really exciting to think: what if there was no life? If we see in every single analysis that there's no hint of life on Mars, I think that would be fascinating. I don't expect that to be the case.

Another possibility is that we get some very old samples and see some prebiotic molecules – chemistry that's still learning to become life. To me, that would be even more exciting, because we have no idea of when these sets of molecules learned to be life as we know it, either on Earth or Mars.

Why would finding no evidence of life on Mars be exciting?

It's hard, of course, to demonstrate complete absence of life; you could always argue that maybe we just didn't hit the right outcrop.

But let's say we find nothing even remotely hinting at life. Here we have this lake on Mars, early in its history when we think life was already present on Earth. There was water. There were minerals. If you see absolutely nothing in these conditions even though they are what we think of as habitable, I think that tells us that life needs something more to become widespread.

Beyond Perseverance and its samples, is there more to be done to keep learning about the potential for life on Mars?

There's always another location to go to on Mars. Jezero crater is not the only crater lake on the planet that existed during this time. There are other habitable environments. I think scientists studying Mars after the Perseverance mission will have plenty of choices in the years to come.

If the landing affected you so much, what do you think it will be like when we finally get these Mars samples back to Earth?

In the middle of a pandemic, I think we needed something good to happen, and that's why so many people wanted all the science and engineering that goes into landing a rover on Mars to succeed. As for what will happen when the samples come back – I can't imagine. It's going to be otherworldly. ∎

Jonathan O'Callaghan is a freelance science journalist based in London. You can follow him on Twitter @Astro_Jonny

New Scientist
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Parental guidance

Your evidence-based guide to getting your kids (and you) through the pandemic

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Join *New Scientist*'s coronavirus editor Catherine de Lange as she looks at issues big and small facing parents as the weeks of the coronavirus crisis roll on, leaving judgment at the door and letting science be the guide.

Catherine
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The science of cooking

Love meat tender

Tasty and tender meat takes good marinades. Testing the theory behind them in the kitchen shows a clear winner, finds **Sam Wong**

Sam Wong is social media editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

For a tandoori marinade:
Yogurt
Salt
Ginger
Garlic
Spices (your choice)

The science of cooking appears every four weeks

Next week

Stargazing at home

AS WELL as adding flavour, marinades are supposed to tenderise meat before it is cooked and make it more juicy. There is plausible scientific theory and evidence to back up these claims, but when I tested some marinades, they weren't all successful.

Salt is common to most marinades, in the main to improve flavour. But it affects texture too, dissolving some muscle proteins. Once salt has diffused into the meat, it draws moisture in from the marinade and ensures less moisture is lost during cooking.

Some marinades include acids such as citrus juice. Acids cause muscle proteins to unravel, which can soften meat. As they change shape, more parts of the proteins interact with water molecules, which may help the meat retain moisture. But if meat spends too long in a marinade that is too acidic, the unravelled proteins bond tightly and squeeze out moisture, becoming tough.

Yogurt, widely used in parts of Asia, and buttermilk, popular in the US, are weakly acidic. But the calcium they contain might also have an effect on meat texture, increasing the activity of enzymes within the muscle that break down proteins.

In Chinese cooking, it is common to use baking soda, or sodium bicarbonate, to tenderise meat before stir-frying. There have been studies showing it to be effective, but the mechanisms aren't well understood.

GETTY IMAGES/ISTOCKPHOTO

Red wine can also have a tenderising effect on meat, partly because it is acidic, but research suggests tannins play a role, too. These polyphenol compounds, found in grape skins and responsible for the astringency of red wine, may react with proteins on the surface of the meat to form sticky substances that prevent juices from being squeezed out.

Some fruits, such as papaya and kiwi, contain enzymes that digest proteins, and these have also been used as meat tenderisers.

So which is the most effective? To find out, I marinated beef cubes for 6 hours in six marinades: a salt solution, sodium bicarbonate solution, lime juice, red wine, yogurt and minced kiwi, all containing the same amount of salt. Then I put the beef on skewers and grilled the cubes for the same length of time.

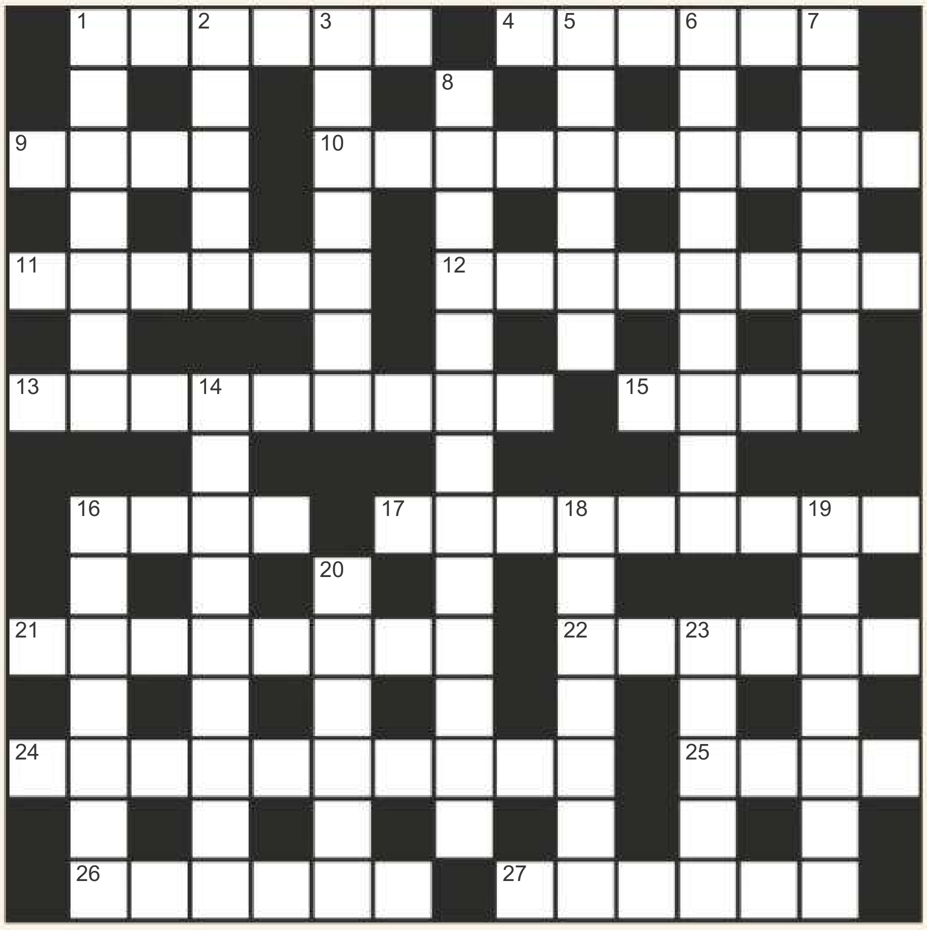
Lime juice, red wine and baking soda all failed, yielding meat that was tougher and drier than the salt solution. The kiwi softened the meat, but the resulting texture was mushy and unpleasant. Only the yogurt marinade improved the meat texture so it was juicy and tender.

It turns out these marinades are more powerful than I expected, and perhaps they would have worked better if the meat had been marinated for less time.

For a reliably tenderising effect and delicious flavour, you can't go wrong with an Indian tandoori-style marinade of yogurt, ginger, garlic, salt and any spices you like. ▮

These articles are posted each week at newscientist.com/maker

Quick crossword #80 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Orville and Wilbur ___, aviation pioneers (6)
4 Layers (6)
9 Sliding conveyance (4)
10 Temperature scale (10)
11 NASA crewed space flight programme (6)
12 Tested; sampled (5,3)
13 Standard of manufacture or performance (9)
15 Lepidopteran, often nocturnal (4)
16 Highest point (4)
17 Movement between areas of lower and higher concentration (9)
21 Mental state that may lead to persecutory or conspiracist delusions (8)
22 Activate (software) again (6)
24 Small adjustment sometimes made to Coordinated Universal Time (4,6)
25 See 18 Down
26 Odorous (6)
27 Type of surgery (6)

DOWN

1 Strabismus (4-3)
2 Large lemur species (5)
3 Hf (7)
5 Argument; dissertation (6)
6 Without water (9)
7 Angular measurement in a spherical coordinate system (7)
8 1984 James Cameron sci-fi film (3,10)
14 Fruit tree in the genus *Rosaceae* (4,5)
16 Mercury, Venus and Earth, for example (7)
18/25 Mesh enclosure that blocks electromagnetic fields (7,4)
19 Hybrids of the pomelo and mandarin (7)
20 Jim ___, US astronaut (6)
23 Stretchy fabric invented in 1958 (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #96

1 Wally Funk, Jerrie Cobb and Jerri Sloan Truhill were members of a group that underwent NASA screening tests and became known as what?

2 The fungus *Hymenoscyphus fraxineus* causes which disease?

3 What is the potent neurotoxin found in the organs of some pufferfish?

4 Physician René Laennec invented which medical device?

5 In what year did James Chadwick prove the existence of neutrons?

Answers on page 55

Puzzle

set by Brian Hobbs

#108 Half time

"I couldn't help but notice," said Sherlock Holmes, "that in the struggle, a clock, with numbers one to 12, had fallen off the wall."

"How interesting," Watson lied.

"In doing so, the clock face had broken into two distinct pieces," continued Holmes. "The numbers on one of the pieces added up to an odd number, while the numbers on the other piece added up to an even number. All digits were present and accounted for. Now, what do you get when you add those two numbers together?"

Watson scoffed. "Not your best puzzle, Sherlock. One plus two plus three, all the way up to 12, whatever that number is."

Sherlock smirked and gave me a sideways glance. "So what do you say, friend? Is our dear Watson correct?"

Answer next week

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Meta memory

When I can't remember something, but know that the memory is in my head, how do I know that I knew it?

Brian Moss
Kingsbury, Warwickshire, UK

Although I am in my 80th year, I seem to have an excellent long-term memory. However, if I can't remember something, I seem to know "where" it is in my brain and can predict with reasonable accuracy how long it will take me to remember it, be it 10 minutes or 2 hours.

I can also predict with similar accuracy if I am unlikely to remember it at all.

Tim Stevenson
Great Missenden, Buckinghamshire, UK

This metaphor may help: the filing system lists the title of the file, but when you try to open it, it is corrupted!

> "If I can't remember something, I seem to know 'where' it is in my brain and can predict how long I will take to remember it"

Elisabeth Norman
University of Bergen, Norway

A sense of knowing that you know something can be described as a feeling of knowing. It is a rating of the likelihood that you will be able to remember something you are currently unable to recall – for example, the answer to a general knowledge question.

Experiencing this sensation doesn't necessarily mean that the memory is actually there and that you will be able to recall it later. However, studies show that the strength of this feeling predicts future memory recall with above-chance accuracy. There are three views on why this is the case.

One is known as the trace access view, which considers that sense of knowing to be the outcome of a metacognitive monitoring of the presence and strength of traces of the relevant memory. A strong feeling indicates that the memory is present and could be retrieved.

A second view is the cue familiarity hypothesis, which suggests that this feeling of knowing reflects the extent to which information presented in a question seems familiar. This sensation can occur even before you try to retrieve the information from your memory. The hypothesis has been explored in the so-called game show paradigm, in which people are asked to rate their feelings of knowing for general knowledge questions immediately after each one is asked, but before they have made any efforts to remember.

A third view is the accessibility account, which says that this feeling of knowing reflects products of the ongoing memory retrieval process. As you try to remember something, you might recall fragments or attributes of your target. For instance, if you are trying to recall the name of an actor in a certain movie, you might remember the first letter of their surname or their haircut.

It is likely that all three factors contribute to a feeling of knowing.

Saif Ahmad
Basingstoke, Hampshire, UK

Our familiarity with computers makes us inclined to think that our brains work in a similar way. However, memories are stored differently in a human brain compared with a computer.

Our memories are made up of various sensory inputs stored in the brain as neuron connections. You might, for example, go outside and experience cold air, the smell of flowers, the sight of a sunrise, a feeling of happiness, etc. When we try to remember an event, the brain recreates the overall experience from stored sensory inputs. There are situations where part of the memory is weaker, and in these cases the brain struggles to recreate the full experience.

In this scenario, you might feel that "something is there", based on the remaining memories of sensations. When the brain is able to find the missing senses from weak, but still intact, neuronal connections, you suddenly remember.

REUTERS/KAI PFAFFENBACH

Why does getting wet in a shower of rain feel so uncomfortable?

This week's new questions

Wet and miserable **Why does it feel so unpleasant to be out in the rain?** ***Rachel Haldane***, *Chelmsford, Essex, UK*

Being green **Why are there no green mammals? There are green fish, amphibians, reptiles and birds – and in a world of green vegetation, surely the camouflage it offered would be advantageous?** ***Aiden McNicol***, *Birmingham, UK*

Weighty waves

Gravitational waves arise when very heavy objects spiral into each other, but is there a lower limit to this? Do I create one when I crash into the sofa after a day of work?

Eric Kvaalen
Les Essarts-le-Roi, France

Every time you move, you create gravitational waves – there is no lower limit. If you change your position, your gravitational influence on other objects changes slightly. That change travels outwards from you at the speed of light. Most of that influence dies out drastically with distance, but a tiny amount doesn't and continues to propagate as waves, carrying away a tiny amount of energy.

Mike Follows
Sutton Coldfield, West Midlands, UK

You create a gravitational wave by collapsing onto the sofa. However, it would be undetectable. After all, gravity is by far the weakest of the four fundamental forces of nature.

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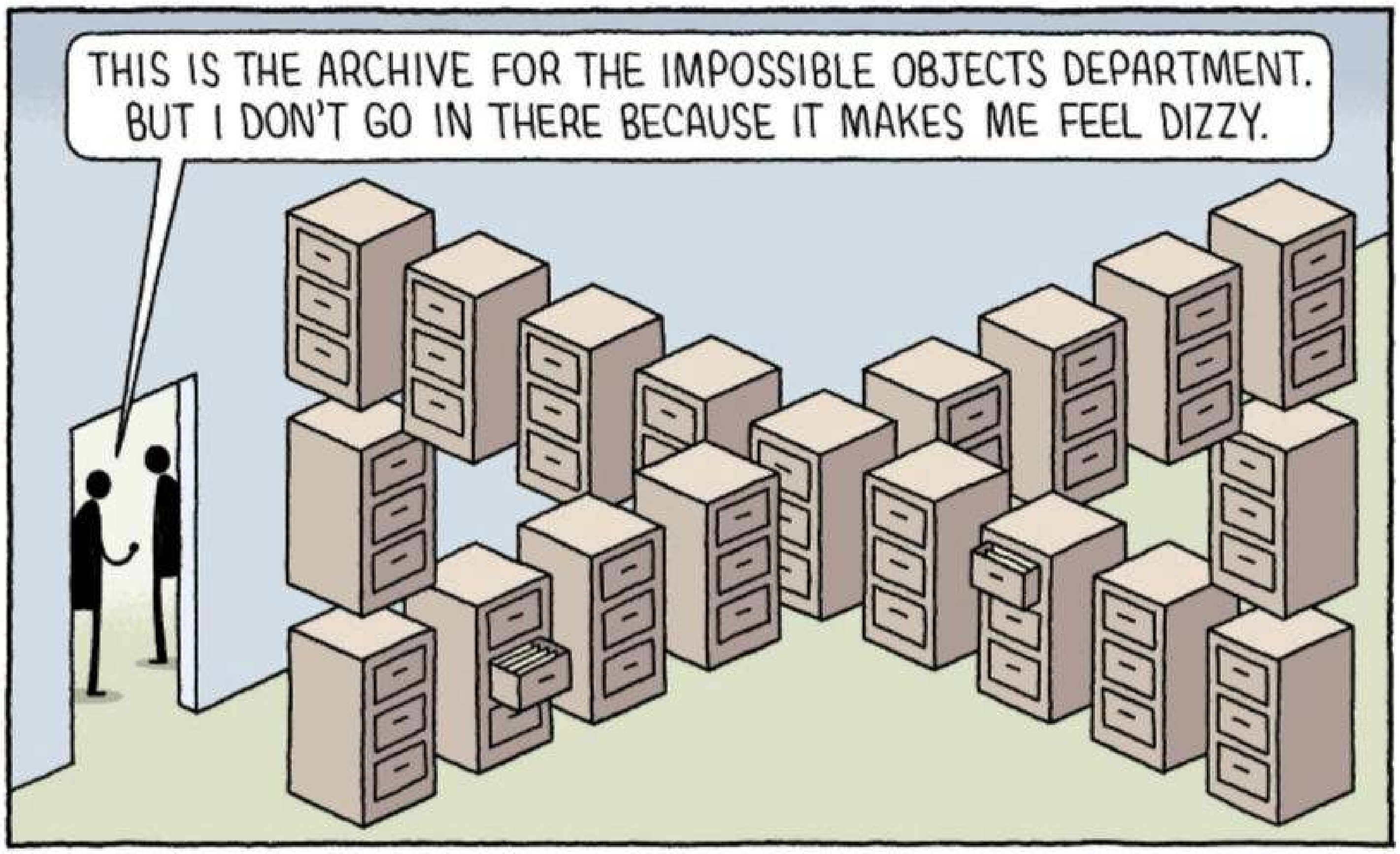
THIS IS THE ARCHIVE FOR THE IMPOSSIBLE OBJECTS DEPARTMENT. BUT I DON'T GO IN THERE BECAUSE IT MAKES ME FEEL DIZZY.

Masses create indentations on the fabric of space-time. If any of these masses accelerate – acceleration includes slowing down and changing direction as well as speeding up – they generate gravitational waves on the fabric, like ripples of water on a pond. Gravitational waves are the gravitational equivalent of electromagnetic waves, and travel at the same speed as light.

The first experimental confirmation that these waves exist came in 2015 when the Laser Interferometer Gravitational-wave Observatory (LIGO) detected some that were generated when two black holes 1.3 billion light years away spiralled into each other. Each was about 30 times the mass of the sun and merged to form an even bigger black hole.

Gravitational waves cause the fabric of space-time to stretch in one direction and contract in the perpendicular direction. The LIGO detectors were only just sensitive enough to detect this disturbance – a change in length of one part in 10^{21}. If the merger of the two black holes had happened as close to us as the sun, then the diameter of Earth would have changed by just 1 metre and the height of a typical person by about 150 nanometres, too small a change to be picked up by our senses.

"When you move, you create gravitational waves that travel at the speed of light, carrying away a tiny amount of energy"

Take a bet

Why do some people like gambling so much? What is the evolutionary root of this behaviour? (continued)

Pauline Grant
Beaconsfield,
Buckinghamshire, UK

I would like to offer another perspective to the previous answers (13 February). People who gamble are exposed to what psychologists call an intermittent reinforcement schedule. Positive reinforcement can be thought of as a reward following a particular behaviour. Perhaps surprisingly, the effect is stronger when the reward is intermittent rather than consistent, resulting in a greater desire to engage in the behaviour if it only sometimes evokes that reward.

There could be a huge advantage to being motivated to repeat behaviours that are rewarded only intermittently, which might explain the determination to continue despite setbacks.

For instance, parents persevere with encouraging young children towards new behaviours even though the child initially can't perform them, and later can only do so sometimes. The adults are subject to intermittent reinforcement yet remain motivated to continue, and the children learn.

There are also many instances of innovation arising from a wish to replicate something that initially happened by accident. ▮

Answers

Quick quiz #96
Answers

1 The Mercury 13

2 Ash dieback

3 Tetrodotoxin

4 The stethoscope

5 1932

Cryptic crossword #54 *Answers*

ACROSS 1 Perseverance, **9** Retinol, **10** Cedar, **11** Good turn, **12** Mesh, **14** Coyote, **15** Raisin, **18** Unix, **20** Paramour, **23** Owlet, **24** Sternum, **25** Biochemistry

DOWN 2 Entropy, **3** Sanctity, **4** Velcro, **5** Rock, **6** Nudge, **7** Earthen, **8** Frog, **13** Palavers, **14** Coulomb, **16** Spooner, **17** Balsam, **19** Igloo, **21** Rome, **22** Itch

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#107 Turning tables
Solution

TABLES × 7 = 999999

For TABLES × 5 = STABLE, T must be 1. (If it were 2 or higher the number represented by TABLES × 5 would be longer than six digits.)

S × 3 ends in T (= 1), so S = 7, and S × 5 ends in E so E = 5. This leads to L = 8, B = 2 and A = 4, making TABLES 142857.

The interesting property of this number is related to the fact that the fraction 1/7 is the recurring decimal 0.142857.

Ever keeps on Given

The world rejoiced as the banking of the possibly good, but mainly just rather big, ship Ever Given at the southern end of the Suez Canal supplied an endless source of memes, a new unit for the horizontally stupidly oversized – about 0.5 Burj Khalifa – and a threat to global commerce and trade that wasn't coronavirus. Or Brexit in UK parts, for that matter.

Our favourite related time-waster is a site brought to our attention by Elizabeth Barner from Leeds, UK: evergiven-everywhere.glitch.me.

Starting from a position that (shame on us) only by zooming out very, very far do we identify as the harbour of Boston, Massachusetts – whose famous tea parties were also some sort of statement about global trade practices back in the day – it allows us to "get the *Ever Given* stuck wherever you want it. Drag and zoom the map to move this big old boat somewhere else. Click the rotate button to get it wedged perfectly. Hit the 'to scale' button to make it approximately the right size. Or you can make it whatever size you feel like: get it stuck in a swimming pool or across the entire Atlantic Ocean."

Great fun, and all in the good cause of encouraging donations to the Boston Public Library's Norman B. Leventhal Map & Education Center, we see.

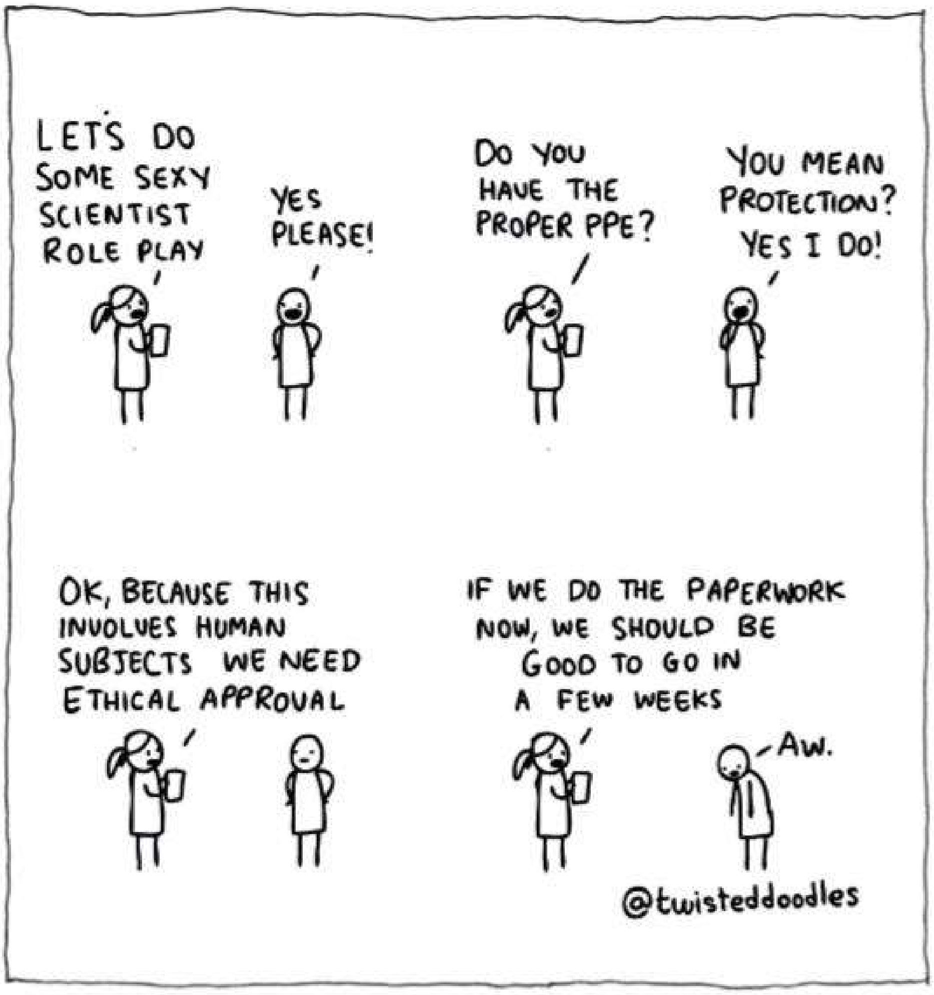
Stressed out

Something has agitated the citizens of Leeds, as Martin Pitt also writes in from that city to add ire to our disparagement of "experiential" units of measurements rooted in no one's experience (27 March).

The example we highlighted from *The Wall Street Journal* of an elephant suspended by a rope the diameter of a table tennis ball is meaningless for its stated purpose of measuring tension, or tensile force, he fulminates. "What the analogy should express is the tensile stress, which is the force per unit area, which would have been clear if they had also expressed it in conventional units such as Newtons per square metre."

We are far from demurring, Martin. Mind you, the whole thing reminds us of the entry that used to stand in the good old *Yellow Pages* telephone directory under "Boring": "See civil engineers".

Twisteddoodles *for New Scientist*


LET'S DO SOME SEXY SCIENTIST ROLE PLAY
YES PLEASE!
DO YOU HAVE THE PROPER PPE?
YOU MEAN PROTECTION? YES I DO!
OK, BECAUSE THIS INVOLVES HUMAN SUBJECTS WE NEED ETHICAL APPROVAL
IF WE DO THE PAPERWORK NOW, WE SHOULD BE GOOD TO GO IN A FEW WEEKS
AW.
@twisteddoodles

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Don't drink the water

We mean that only in self-referential jest, of course, as we do when we also say that our natural inclination on encountering any message beginning with the words "as a chemist" is to avert our eyes and hurry onwards in the hope we haven't been seen.

Bill Appelbe writes in from Toronto, Canada, to take issue with our ridiculing of hydrogenated water as a facial exfoliation agent (13 March). Hydrogenated water, or H_3O^+, Bill points out, also using equations, is in fact a natural product of the ionisation of water in most environments save interstellar space – an environment where, he rightly points out too, few *New Scientist* readers are to be found, enjoying a facial scrub or not.

We stand corrected, Bill. We aren't so sure about your advice to use a concentrated solution of sulphuric or hydrofluoric acid to get a really good dose of hydrogenated water with all its exfoliation benefits, but we understand you were writing as a chemist, not a beautician.

Oversight oversight

What we can only moodily and obliquely refer to as "other duties" leads Feedback to the website of the Oversight Board (motto: "Independent Judgment. Transparency. Legitimacy"), a body whose mission is so transparent it is apparently not necessary to state in its name what its independent judgement is lending legitimacy to.

To fill in the gaps, it has to do with a well-known social media company, which by appointing said board hopes to convince the world – we paraphrase, slightly – that while its medium may sometimes seem antisocial, it isn't actually media, so doesn't need regulating as such.

Not increasing our faith about the outfit's resourcing is that, approaching its website using a well-known open-source browser, we see a confused mishmash of text and hyperlinks resembling the web circa 1999. Repeated links saying things like "A person scrutinizing a sphere she's holding in her hand, while shapes and clouds float around her", suggest images, yet lead to more text. The only thing that isn't entirely 20th century is a warning that appears hovering above a "Share" link saying that if we click on it, a well-known social media company will be able to track our visit.

Oddly, when we use a well-known web browser associated with a well-known search company, we are transported back to the third decade of the 21st century, drawings of people scrutinising spheres surrounded by other geometry included. The power of big tech, eh?

Shining example

In a policy violation that our own Oversight Board shall investigate forthwith, we highlight Marc Abraham's discovery of a paper from 2005. Very much in the spirit of a paper on incontinence by J. W. Splatt and D. Weedon that brought to life the monster of nominative determinism the best part of three decades ago – 5 November 1994, to be precise, we remember it as if it were yesterday – "Transparent Organic Light-Emitting Devices With LiF/Mg:Ag Cathode" is by B. J. Chen, X. W. Sun and S. C. Tan. ▮

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